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XXVII

AN EXPERIMENTAL STUDY OF AUDITORY DAMAGE FOLLOWING BLOWS TO THE HEAD

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The clinical features of deafness resulting from blows to the head were discussed in a previous paper.[1] Case histories and audiograms were presented. It was observed that some patients experienced hearing losses even though there was no apparent injury to the bony labyrinth capsule. The hearing losses were most severe for the tones from 3000 to 8000 cps. In severe cases the entire audible frequency range was involved, with the greatest loss for the high frequencies. The audiograms were similar to those of patients suffering from acoustic trauma due to air-borne sounds of high intensity.

From the Divisions of Otolaryngology and the Laboratory of Physiological Psychology of the University of Chicago.

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Presented in part before the American Academy of Ophthalmology and Otolaryngology Oct. 10, 1950.

The nature of the lesion which is responsible for this inner ear type deafness has been the subject of several investigations. Brunner,[2] Stenger[3] and Linck[4] were able to demonstrate hemorrhages in the scala tympani in animals subjected to head blows. Stenger also demonstrated petechial hemorrhages in the cochlear nerve and degeneration of Corti's organ and the spiral ganglion cells. In a study on cats Wittmaack[5] found localized injury to the organ of Corti and spiral ganglion. The injury was most severe in the middle coil, next the apical coil and least severe in the basal coil. There appeared to be a need for a more careful quantitative experiment. The present study, therefore is an analysis of the relationship of inner ear pathology to deafness in animals subjected to head blows.

THE EXPERIMENTAL PROCEDURE

Step 1. Ten healthy adult cats were used. In each animal the auditory bulla of one ear was opened through a ventral midline incision and the cochlea destroyed by probing through the round window. There was a severe vestibular reaction for five to seven days following this destructive labyrinthotomy. Nystagmus was toward the opposite side and falling toward the homolateral side.

Intraperitoneal nembutal anesthesia, supplemented by intravenous pentothal, was used in all surgical procedures. Intramuscular penicillin injections were given for five days postoperatively in doses adequate to assure an effective blood level.

Step 2. Each animal was then trained to respond to auditory stimuli by walking forward in a rotating cage. An easily audible pure tone was presented for three seconds and immediately followed by shock and buzzer of one second duration. When the animal had learned to respond to the tone with a forward movement, the shock was omitted except for occasional reinforcement (Culler, et al,[6] Neff[7]). Sensory generalization was marked so that the response was readily established for frequencies in the range 125 to 16,000 cps. At each test frequency the intensity of the stimulus tone was then decreased by 5 decibel steps during repeated tests until the threshold for hearing was established. By this procedure an audiogram was obtained for each experimental animal.

During the testing procedure, the experimenter sat at a control panel outside a sound-proofed room and observed the animal through a one-way window. Current for shocking the animal was supplied to the crossbars of the rotating cage by a potentiometer of wide intensity range. Pure tones were produced by a loud speaker activated

by the amplified current from an audio-oscillator. The intensity of the tone was controlled by proper attenuators. By impressing the output of the audio-oscillator and a frequency-standard oscillator on the plates of a cathod ray oscilloscope and obtaining the desired Lissajous figure, stimulus frequency was accurately checked.

An animal was considered adequately trained when the threshold for each frequency varied not more than plus or minus 5 db in repeated tests.

Step 3. After hearing tests had been obtained, each animal was anesthetized, the skull exposed by a midline scalp incision, and a blow delivered to the head. The head was held in a fixed position on a metal table top, a metal rod measuring one inch in diameter and weighing two pounds was placed firmly on the skull, and a blow was delivered to the rod by means of a one pound mallet. Several blows of increasing force were usually given. The scalp incision was then closed with silk sutures.

In eight experiments the blows failed to produce a deafness and the operation had to be repeated after one or two weeks' recovery period.

Step 4. Auditory testing was resumed two days after administering the head blows and the stimulus limens were again determined for all test frequencies. The animals were tested one to three times a week until they were sacrificed.

Step 5. Cochlear response tests were performed on five animals. The cat was anesthetized with intraperitoneal nembutal and the auricle of the experimental ear was amputated. Pure tones from a PDR - 10 Permaflux headphone activated by an audio-oscillator were delivered through a plexiglas earpiece inserted tightly into the external auditory canal. The current through the phone was controlled by an attenuator calibrated in one decibel steps. Sound pressure was measured at a point about 3 mm from the drum membrane by a calibrated microphone and probe. The probe was incorporated into the ear piece. A platinum wire electrode was placed on the round window membrane and an indifferent electrode on connective tissue in the incision.

The electrical potentials were measured, after amplification, by a Hewlett-Packard wave analyzer used as a voltmeter. The recording apparatus was calibrated so that the electrical response could be determined in microvolts. The threshold for each frequency was determined as that intensity of sound pressure which gave a one microvolt response.

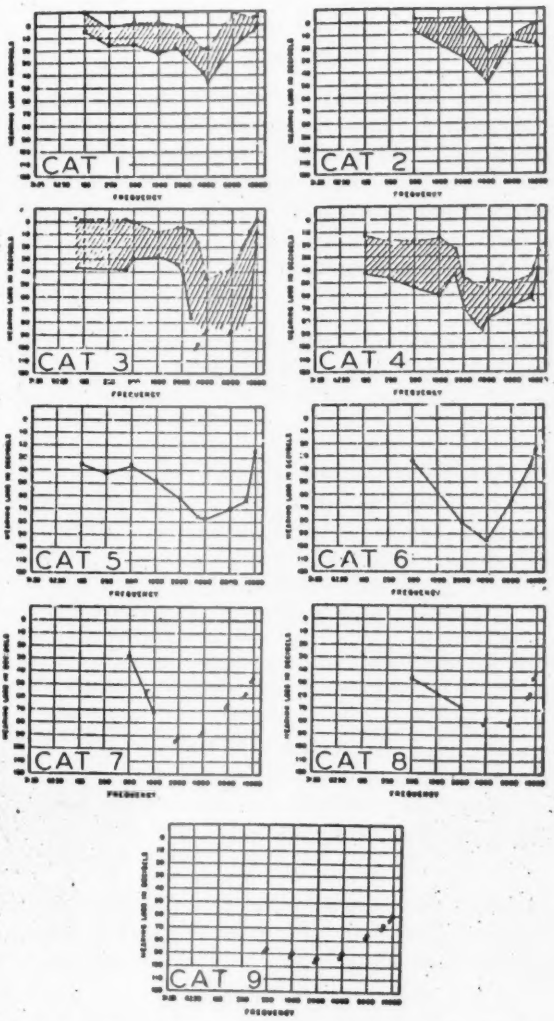

Fig. 1.—Conditioned response type audiograms of cats subjected to head blows. The amount of hearing-recovery occurring during three week period following the blows is seen in the first four audiograms. The arrows in the last three audiograms indicate that the frequencies were not heard at those intensities.

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Step 6. At varying periods of time following the head blows the animals were anesthetized and perfused with normal saline followed by 20 per cent formalin solution. The brains and temporal bones were removed and prepared for histological examination. The temporal bones were sectioned at 20 micra and every fifth section was stained and mounted. Each cochlea was graphically reconstructed according to the method of Guild.[8]

RESULTS

Audiograms: Post concussion audiograms were obtained on nine animals (Fig. 1). No audiogram could be obtained for cat 10 because brain damage produced a partial paralysis and behavioral tests could not be made. Three animals (cats 1, 2, and 3) had hearing losses which were rather sharply confined to the 3000 to 8000 cps range. Five animals (cats 4, 5, 6, 7 and 8) suffered more widespread and severe hearing losses. Cat 9 had complete loss for all tones in the range tested, 500 to 16,000 cps.

In order to produce hearing losses it was found that the blow to the skull had to be severe enough to produce respiratory arrest, pupillary dilatation, loss of corneal reflex, and occasionally convulsive seizures.

The degree of deafness usually varied directly with the severity of the cerebral concussion produced by the head blow. There were exceptions to this generalization, however: in one case a severe hearing loss followed a mild concussive blow, and in another case a mild hearing loss followed a concussive blow that was so severe that artificial respiration was required for five hours.

Deafness was more easily produced when the blows were delivered to the skull near the experimental ear. This finding agrees with the observations reported for human patients.[9] Blows to the contralateral side of the skull failed to produce deafness in four experiments. Blows over the vertex of the skull produced a mild deafness in two of five animals. Deafness was produced in seven out of eight attempts when the blows were delivered over the temporal bone near the experimental ear.

There was typically 15 to 40 decibels recovery of hearing acuity over the frequency range tested during the first two weeks following the head blow. This recovery is shown in the first four audiograms in Figure 1.

The losses shown for cats 1, 2, 3, 4, 7, 9 and 10 are probably permanent. In the cases of cats 5 and 8 final hearing tests were

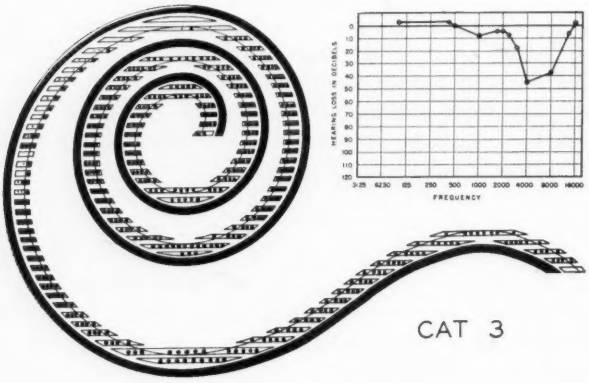

Fig. 2.—Audiogram and cochlear reconstruction of Cat 3 killed on the twenty-second day. The data from the original graphic reconstruction of the ear were transferred to a printed "standard" spiral diagram as shown here. The standard was developed as an average in length and contour of ten cat ears. A slight adjustment was made to prevent crowding of the dorsal arc of the second and third coils. The space between the spiral parallel lines was arbitrarily used to demonstrate the condition of the radial nerve fibers, the blackened area representing the estimated percentage of nerve fibers remaining. Each quadrilatral box represents an organ of Corti and the dots represent hair cells. A large dot is a normal hair cell, and a small dot is an abnormal hair cell. In this animal there is a hearing loss in the 3000 to 8000 frequency range. There is damage mainly to the outer hair cells in a region 2.75 mm long in the upper basal coil.

made 48 hours after the head blows had been administered. The audiograms of these two animals may reflect reversible as well as permanent hearing losses.

Cochlear response tests: Thresholds for microphonic response were established for frequencies from 250 cps to 16,000 cps at octave intervals for 5 cats. In each animal the threshold for electrical response was below normal throughout the frequency range. The thresholds as determined by electrical tests did not agree with the audiograms determined by behavioral methods. Whereas the audiograms showed hearing losses more severe for the high tones, the losses for microphonic thresholds were fairly uniform for all frequencies. For Cat 5 the audiogram indicates a severe loss of function while the electrical response curve shows an average loss of only 9 db. The conditioned response audiogram of this animal was taken 48 hours after the head blow and 20 to 40 db. of hearing improvement for most frequencies probably would have occurred within two weeks.

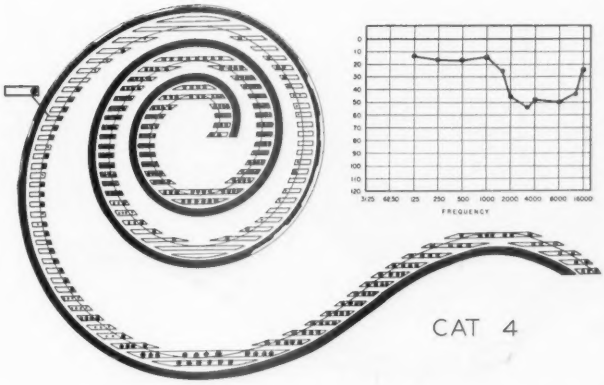

Fig. 3.—Cat 4, sacrificed on the nineteenth day had a 50 db hearing loss of the range between 1500 and 16,000 cps and had a 9.5 mm lesion in the cochlea. Most of the outer hair cells are missing and some of the inner hair cells are injured or missing. Estimated nerve fiber damage is less severe and less widespread than the damage to the end-organ.

No microphonic responses were obtained for Cat 9. This animal also failed completely on the behavioral tests, i.e., no conditioned responses could be obtained for any tones in the frequency range tested.

Pathology: *Skull and Brain.* Cats 5, 7, 8 and 10 had skull fractures which were confirmed by autopsy. The temporal bone was involved in only one cat (Cat 7) and this was a small linear streak through the posterior semicircular canal causing no significant labyrinthine reaction. In no instance was there bleeding from the ears. There was gross brain injury in Cats 1, 5, 8 and 10. The brain of Cat 1 showed two areas of necrosis in the cortex of the left parietal lobe. An intravital trypan-blue stain was used on Cat 5. There was mild diffuse superficial cortical injury and mild subarachnoid hemorrhage but sections of the brain were free of dye stains. Cat 8 had a recent hemorrhage and thrombosis in the left temporal lobe encroaching on the anterior ectosylvian gyrus. There was a contrecoup lesion on the opposite side in the temporal polar gyrus and the inferior part of the sylvian gyrus. The auditory cortex was not involved. There was extensive cortical atrophy and traumatic cyst formation of the left frontal and parietal lobes of the brain of Cat 10. A small traumatic cyst occurred in the right parietal area of the brain and a subarachnoid hemorrhage was found over the dorsum of the medulla.

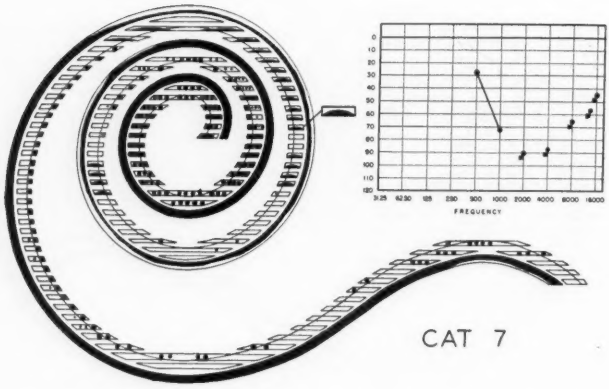

Fig. 4.—Cat 7 was sacrificd at six weeks. The hearing threshold for the 500 cps frequency is 28 db and for 1000 cps is 70 db. There was no response to higher frequencies at the maximum intensities available, e.g. the animal did not respond to the 2000 cps frequency when delivered at 90 db above the animal's pre-concussion threshold. A severe lesion involves the lower 18 mm of the cochlea. Nerve fiber degeneration is present in 9 mm of the middle region of the cochlea.

Microscopic sections were made of the brains of Cats 1, 4, 5 and 10. There was no evidence of damage to any tracts or centers of the auditory nervous system. In none of the 10 ears was there evidence of tearing of the VIIIth nerve or of bleeding in the internal auditory meatus or in the porus acousticus internus.

Middle Ear. The middle ears and auditory bullae of the experimental ears of Cats 6,* 7 and 9 contained gray mucoid material and hyperplastic mucosa. Since this was apparently a long standing chronic condition, it is probably safe to assume that it had the same effect on both the pre- and post-trauma audiograms. The middle ears of all other cats were normal.

Inner Ear. The slightest detectable inner ear changes consisted of a derangement of the outer hair cells and their supporting cells. The hair cells appeared shorter and wider and out of line and their nuclei appeared smaller than in normal ears. A more severe injury consisted of loss of the external hair cells, only a few pale strands remaining where the hair cells should be (Fig. 7*a*). Further progressive stages of injury consisted of disruption and loss of outer

*The post-concussion audiogram of Cat 6 showed a severe 1000 to 12,000 cps depression. However, the cochlea was improperly prepared and is not available for study.

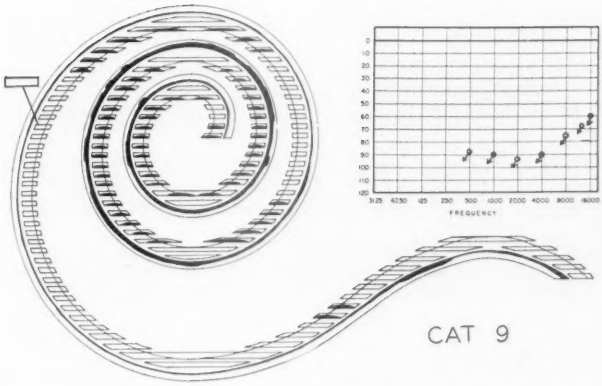

Fig. 5.—Cat 9 did not respond to the test frequencies at the intensities indicated up to four months after the head blow. There is total absence of hair cells.

and internal hair cells (Fig. 7*b*) flattening of the organ of Corti (Fig. 8*a*) and, finally, complete disappearance of the organ of Corti (Fig. 8*b*). These pathological findings are like those reported by Lurie et al,[10] Perlman[11] and Lindquist[12] for intense air-borne sound stimuli.

Degeneration of nerve fibers and spiral ganglion cells was present in all animals except Cats 2, 5 and 8. Cat 2 had a normal organ of Corti throughout so that neural degeneration is not expected and Cats 5 and 8 were sacrificed 48 hours post-trauma before neural degeneration could possibly occur. The nerve fiber and ganglion cell degeneration occurred in the same region of the cochlea as the end organ damage but was slightly less widespread (Cats 1, 3, 4, 7, 9 and 10). A disparity appears to exist in that the hair cell damage is uniformly more severe than the ganglion cell and nerve fiber degeneration. This discrepancy was less apparent in the guinea pig experiments of Perlman[11] in which the animals were subjected to air-borne shock pulses.

There was atrophy of the stria vascularis in all coils in Cat 9. In the other animals the stria vascularis was not significantly changed. In the basal coil of Cat 9 there was an extensive tear in Reissner's membrane and the tectorial membrane, and the basilar membrane was torn from the spiral ligament at one point. No significant changes were detected in the mesothelial cells. The group of cells is not as well developed in the cat as in the guinea pig.

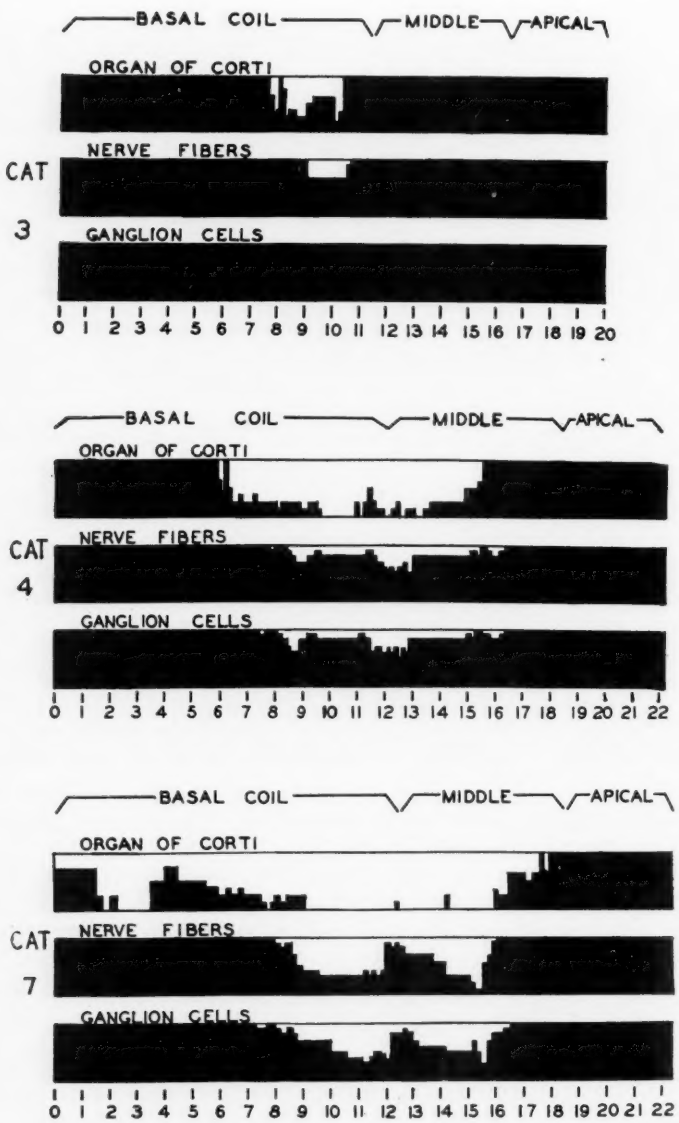
BASAL COIL
MIDDLE
APICAL
ORGAN OF CORTI
NERVE FIBERS
CAT 3
GANGLION CELLS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
BASAL COIL
MIDDLE
APICAL
ORGAN OF CORTI
NERVE FIBERS
CAT 4
GANGLION CELLS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
BASAL COIL
MIDDLE
APICAL
ORGAN OF CORTI
NERVE FIBERS
CAT 7
GANGLION CELLS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

Fig. 6.—Cochlear charts for three cats. The height of the black filling represents the estimated proportion of normal elements. The position is indicated as distance from the basal end of the cochlea.

Blood was found in the cochleas of five cats (1, 5, 7, 9 and 10). The red blood cells appeared normal in size, shape and staining characteristics. There was no evidence of tissue reaction due to the blood. Perlman[13] made a study of the healing process of the labyrinthine capsule following perforation injuries. There was blood in the cochleas of several animals which had lived thirty days and there was no evidence that it had acted as an irritant.

DISCUSSION

The hearing loss resulting from a blow to the head (cat) appears to be due to direct damage of the organ of Corti with secondary degeneration of nerve fibers and spiral ganglion cells supplying the area. The slightest hearing losses produced were in the form of restricted losses for tones in the 3000 to 8000 cps range and were associated with inner ear damage in the upper part of the basal coil. Cat 1 had a mild hearing loss at 4000 cps and the end organ damage was located in a 1 mm area in the upper part of the basal coil. Cat 3 had a moderately severe hearing loss for the 4000 and 8000 cps frequencies and the damage was located between 7.75 and 10.5 mm from the basal end (Fig. 2). The animals with more severe hearing losses had more widespread damage in the inner ear. Cat 4 had a hearing loss involving the range between 2000 and 12,000 cps and end organ damage extending from 6 mm to 15.5 mm from the basal end of the cochlear duct (Fig. 3). Cat 7 with a profound deafness for all tones above 500 cps had damage to the organ of Corti throughout the lower 18 mm of the cochlea (Fig. 4). Cat 9 responded to none of the frequencies tested (500 cps to 12,000 cps) and the end-organ damage was severe throughout the entire length (21.8 mm) of the cochlea (Fig. 5).

The inner ear damage in Cats 5 and 8 was less severe than was to be expected from the audiograms. The explanation for this discrepancy may be that the audiograms were made and the animals were sacrificed 48 hours post-trauma, before the usual partial recovery of hearing could occur. Cat 5 for example had a hearing loss involving the frequency range from 125 cps to 12,000 cps but damage to the organ of Corti extended only from 8.25 mm to 13.1 mm. Cat 8 responded to 500 cps and 2000 cps only at high intensities and to none of the higher frequencies at maximum intensity but had damage in the cochlea involving only the area between 5.75 mm and 13.5 mm. It appears, therefore, that the changes which are responsible for reversible hearing losses are not demonstrable by ordinary histological techniques.

Let us compare the degree of hearing loss for 4000 cps with the severity of inner ear damage in the upper part of the basal coil.

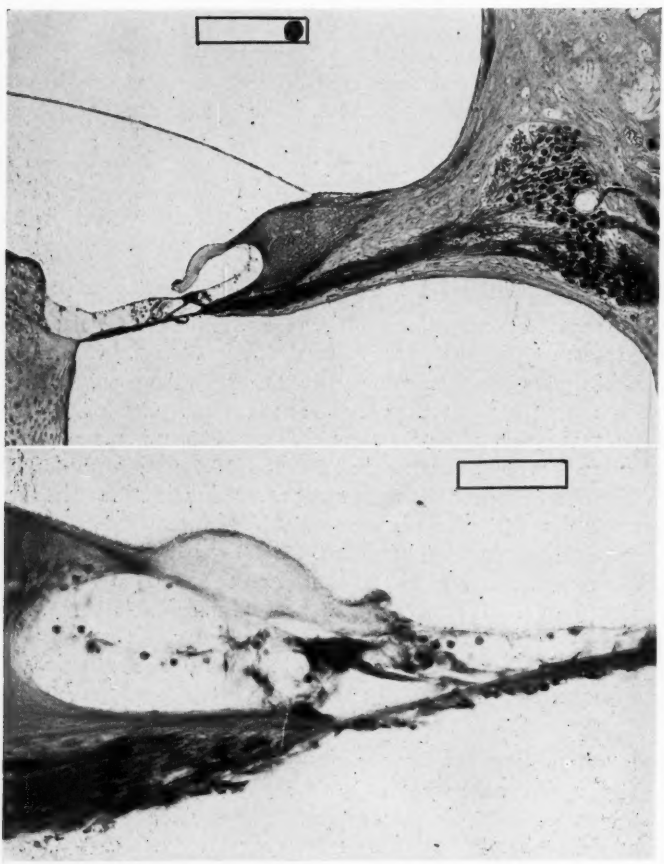

Fig. 7.—*a*. From the cochlea of Cat 4 (See Fig. 3). The outer hair cells are missing. Only a few amorphous strands remain in this region. The inner hair cells, radial nerve fibers and ganglion cells appear normal in this region.

b. From the cochlea of Cat 5. Severe disruption of the organ of Corti in the upper basal coil has resulted in loss of inner and outer hair cells and supporting cells, although the pillars remain. The tectorial membrane appears to be adherent to remnants of the organ of Corti. The animal was killed 48 hours after the injury so that degeneration of the nerve fibers has not yet occurred.

Cat 1 had a 20 db hearing loss for 4000 cps and the upper basal coil contained both inner and outer hair cells although some of them appeared abnormal. Cat 2 with a 20 decibel loss for this frequency had no demonstrable inner ear pathology. Cat 3 had a 44 db loss for 4000 cps. In the upper basal turn there was almost complete loss of outer hair cells but fairly normal inner hair cells (Fig. 2). Cat 4 with a 50 db loss for 4000 cps had almost complete loss of outer hair cells plus approximately 50 per cent loss of inner hair cells in the upper basal coil (Fig. 3). Cats 7, 8 and 9 did not respond to 4000 cps at maximum intensity and their cochleas had total loss of hair cells and flattening of the organ of Corti in the upper basal turn.

A 20 db hearing loss therefore appeared to be consistent with injury to (but not total loss of) the external hair cells. The findings in Cat 2 indicate that a hearing loss may occur without the injury being histologically demonstrable. A 40 db loss seems to be consistent with a loss of outer hair cells only. Hearing losses greater than 40 db are associated with loss of the outer hair cells plus injury to the inner hair cells. Total loss of hair cells in the upper basal turn results in deafness for 4000 cps for intensities up to 100 db above the normal threshold.

There also appears to be a rough correlation between the severity of inner ear damage and the degree of elevation of the cochlear microphonic response thresholds. Of the cats tested, Cats 1 and 5 had the least injury to the inner ear, the lesions extending over 1 mm and 4.5 mm of the cochlea respectively and they had the least average elevation in the cochlear response thresholds, 22 db and 9 db respectively. Cats 4 and 10 had more widespread inner ear lesions, extending over 9.5 and 12 mm respectively and the cochlear response thresholds were raised an average of 33 db and 32 db respectively. Cat 9 had a severe injury to the inner ear throughout the entire 21.8 mm of the cochlea and gave no cochlear response to any of the test frequencies.

These findings are in general agreement with those of a number of recent investigators. In an experiment on stimulation deafness Lurie, et al[10] were able to demonstrate degenerative changes, rupture and dislocation of the organ of Corti from the basilar membrane in guinea pigs subjected to pure tones of high intensity. Mild degrees of injury were localized but severe forms were more widespread. The thresholds for cochlear microphonic responses in their animals showed some general correlation with the anatomical changes in the organ of Corti but the parallelism was variable. Wever and Smith[14] working with guinea pigs which were stimulated by pure tones of high intensity were able to produce localized areas of injury in the inner ear.

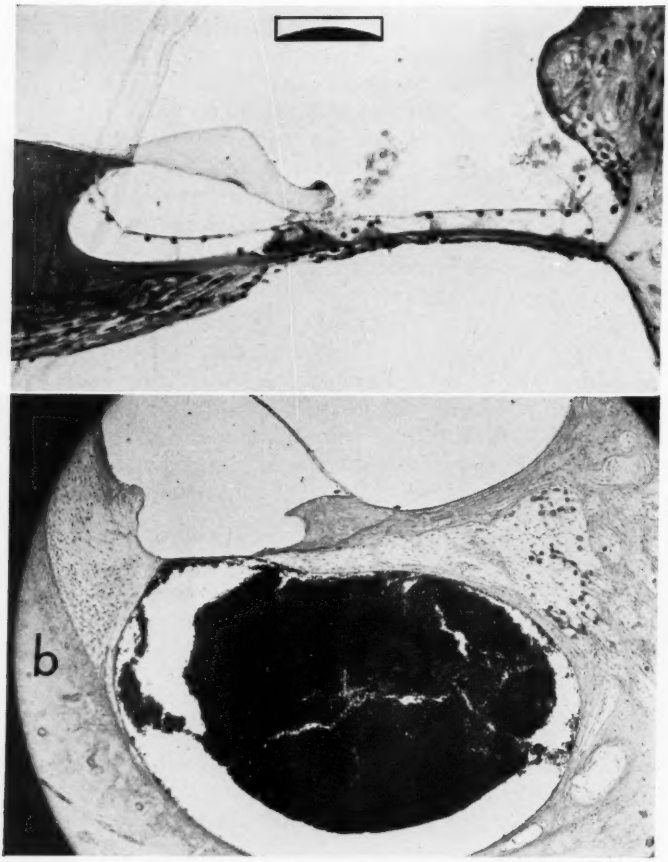

Fig. 8—*a.* Organ of Corti from the upper basal coil of Cat 7 (See Fig. 4). The end-organ has been reduced to a few pale staining cells. There is a decrease in the number of radial nerve fibers.

b. A view through the basal coil of Cat 9 (See Fig. 5). The basilar membrane is denuded and the tectorial membrane is absent. There is blood in the scala tympani. There is almost total loss of nerve fibers and ganglion cells.

Nevertheless, the cochlear response thresholds showed an elevation for all frequencies tested with considerable variation for different animals. They found poor correlation between the severity of cochlear injury and the sensitivity of the ears as measured by the cochlear microphonics.

Davis, et al[15] tested the hearing by the conditioned response method and recorded the microphonic responses of several cats in which an inner ear lesion was produced by a drill or cautery. They reported a fair correlation between these tests and the location and severity of pathological changes in the inner ear.

Lindquist[12] exposed cats to blast impulses from .32 calibre blank cartridges. He measured the hearing deficits by the conditioned response method and found the maximum losses to be in the frequency range of 1000 to 8000 cps. Animals with mild hearing losses had no significant inner-ear pathology. In animals with severe hearing losses, histological examination of the cochleas revealed hair-cell damage and degeneration of the nerve fibers and spiral ganglion cells with the most severe damage occurring in the upper basal and lower middle turn.

Perlman[11] exposed rabbits to shock pulses produced by the explosions of blank .32-calibre cartridges. The auditory function of the animals was tested by recording the threshold of the tensor tympani reflex in response to pure tones. The degree of inner ear injury correlated fairly well with the severity of functional loss as measured by this method. Total loss of the tensor tympani muscle reflex was noted however in animals with restricted inner ear lesions. The most severe histological changes were located in the upper end of the first coil.

The results of our experiment shed no further light on the reason why the particular hearing range from 3000 to 8000 cps is involved in shock pulse injury. We know that the ear is more sensitive to that frequency range. It may be that the same factors which control the sensitivity of the ear to certain frequencies make it most susceptible to injury. A possible inherent fragility of the structures in the upper part of the basal coil has long been considered. Possibly the explanation lies in the physical properties of the stimulus.

It appears that a blow to the head produces an inner-ear disturbance which is similar to that caused by intense stimulation by sound or blast impulses.

The origin of the blood in the cochlea is not clear. The possibility of intracochlear hemorrhage resulting from excessive pressure during perfusion seems unlikely.

It is possible that blood cells from a subarachnoidal hemorrhage passed through the cochlear aqueduct into the cochlea. It is known that blood cells injected into the subarachnoidal basal cisterns will find their way into the cochlea.[16] This source does not explain the finding of blood in the cochlear duct of Cat 10.

Small hemorrhages may have occurred directly into the cochlear scalae. In none of the cochleas, however, could a bleeding site be found. It is entirely possible that in hemorrhage from small intracochlear vessels, the blood does not clot because of immediate dilution with cochlear fluids. A minute fibrin platelet mass occurring in such an area might easily escape detection even as early as 48 hours after the injury.

SUMMARY

Ten conditioned cats were subjected to head blows. The post concussion audiograms of these animals revealed hearing losses which were most severe for the high tones, particularly in the region of 4000 cps. Gross and microscopic studies failed to demonstrate significant pathology in the middle ears and brains. Graphic reconstructions of the cochleas were made. The primary injury was found to be a degenerative change in the organ of Corti. The upper part of the basal coil was most susceptible to injury. In the order of severity, the recognizable stages of end organ damage were: 1) loss of the external hair cells, 2) loss of the external and internal hair cells, 3) flattening of the organ of Corti and finally 4) complete disappearance of the organ of Corti. There was secondary degeneration of the nerve fibers and ganglion cells supplying the damaged regions of the cochlea.

Blood was found in the cochleas of five animals. The red blood cells were well preserved and appeared to cause no reaction within the labyrinth for periods as long as four months.

It appears that a blow to the head may create a pressure wave in the skull bones which is transmitted through bone to the cochlea just as a pressure wave in air is carried by the conducting mechanism. These pressure pulses result in displacement of the basilar membrane as occurs during the analysis of acoustic stimuli. Intense stimulation apparently produces violent displacement of the basilar membrane causing injury to the accompanying organ of Corti.

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XXVIII

ADENOMA OF THE BRONCHUS

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At the Groningen University Clinic 17 cases of adenoma of the bronchus were seen, 2 cases of cylindroma and one case of adenoma of the trachea. Here, too, the adenoma of the bronchus was found to predominate in females and in young adults. Out of our 17 patients 11 were females, 12 were under 40 years of age. In this respect it sharply contrasts with carcinoma.

We mean to discuss the origin and the nature of this tumor, and the therapy on both of which opinions are still divergent.

ORIGIN

Concerning the origin of this tumor a great number of theories exist; the best-known ones are the following:

1. It is a basal cell carcinoma in the sense of Krompecher[1] (Geipel[2]).

2. It is a carcinoma of slight malignancy (Alexander[3]).

3. It is a hamartoma of the bronchus in the sense of Albrecht,[4] originating from an abortive bronchial "anlage" (Womack and Graham,[5] Churchill[6]).

4. It is partly an epithelioma, partly a mesenchymal tumor, viz. an immature angioma (Deelman[7]).

5. It is comparable to the carcinoids of the appendix (Hamperl[8]).

6. It is an adenoma originating in the excretory ducts of the seromucous glands (Jackson and Konzelman[9], Kramer and Som[10]).

7. It is a tumor originating in the seromucous glands and comparable to the tumors of the salivary glands (Brock,[11] Leegaard,[12] Policard,[13] Jacob,[14] Holinger,[15] Vos,[16] Huizinga[17]).

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We hold the view that the seventh theory must for the time being be considered to be nearest to the truth. It is easy to find a number of arguments telling more or less strongly against the other theories: 1. The basal cell carcinoma is nearly always ulcerative, the adenoma is almost always covered with normal mucosa. 2. Indications that the adenoma has developed from this superficial epithelium are never found. 3. The sex and age incidence show such marked differences that the supposition that there must also be a fundamental difference between adenoma and carcinoma, is almost ineluctable. 4. Hamartomas are nearly always localized in the periphery of the lung, the adenoma, on the other hand, near the hilus pulmonis. 5. In the carcinoids argyrophil cells are found, which are missing in the adenoma. 6. In the adenoma oncocytes are found with comparative frequency, whereas these are not found in the carcinoid.

In Groningen we have been convinced for many years, together with the pathologico-anatomist Vos, that the adenoma of the bronchus must be considered as a special localization of the parabuccal mixed tumor. This name was introduced by French investigators. It denotes a group of tumors, which at the moment are still rather puzzling to the pathologico-anatomists. To these belong in the first place the mixed tumors of the salivary glands. Several of these mixed tumors display the picture of a cylindroma. This is, as we know, a tumor with remarkably regular clusters and tubules of epithelium, divided by a connective tissue, which in typical cases displays mucous degeneration, but may also contain much hyalin. The tubules, too, are often filled with mucous or hyaline degenerated connective tissue. Cylindromas also occur in many other places, e.g. the upper jaw and the palate. A certain connection with the mixed tumor of the salivary glands is probable, and this has caused them to be united as parabuccal mixed tumors. The same tumors, however, also occur in the skin, and have been described even on the leg so that the word parabuccal is, as a matter of fact, not quite correct. Moreover during the last years serious doubts have arisen, whether the mixed tumors are really composed of the derivatives of two primary germ layers; most investigators class them among the epithelial tumors. But the word parabuccal mixed tumor has found acceptance, and expresses a certain concept. They are tumors, originating in the seromucous glands, keeping the mean, as concerns their clinical course, between benignant and malignant growths. Some of them remain benignant for years, these are usually provided, then, with a fibrous capsule. Others, however, display an infiltrative growth; rarely metastasis takes place. Some cases of cylindroma must perhaps be considered as carcinoma of a special structure. But also in the malignant cases the course of the illness is usually different

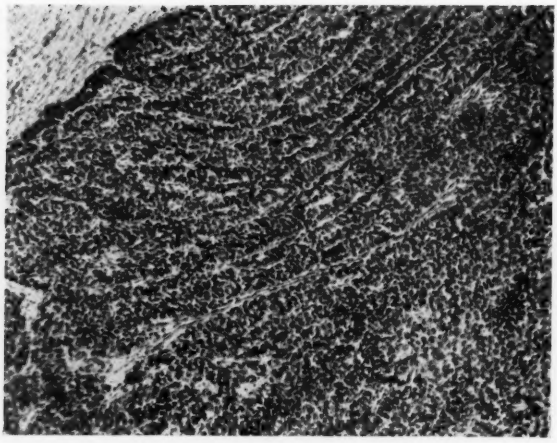

Fig. 1.—Magnification 100 x. Typical adenoma of the bronchus.

from, and particularly more protracted than in cases of carcinoma and sarcoma. While in this group the cylindroma is nearest to the carcinoma, the adenoma of the bronchus, which must also be counted among this group, is near to the benignant tumors.

Our conception, therefore, is a slightly sharper formulation of the theory sub 7. A number of arguments support this, which will be discussed below.

A. In the typical cases the adenoma of the bronchus shows a characteristic picture. Fig. 1 shows a fine example, to which various tumors bear a complete resemblance. The tumor consists of small cubical or polygonal cells with a very intensively stained nucleus, in which a fine chromatinic structure is visible. The cells are arranged in alveoli or strands, divided by stroma, containing a remarkable number of vessels. This explains the spontaneous hemorrhages and the occasionally profuse bleeding when biopsy is performed. Often, as is also visible in Fig. 1 the cells are arranged in garlands; the cells are often arranged in palisade formation. The cells are hardly ever divided and atypia does not occur. Great regularity is characteristic for the whole picture.

Tumors of the same structure are found in the salivary glands. Among the tumors in the archives of the Pathologico-Anatomic Laboratory in Groningen (Prof. Vos) three tumors proved to bear a close resemblance to the adenoma of the bronchus so that in these

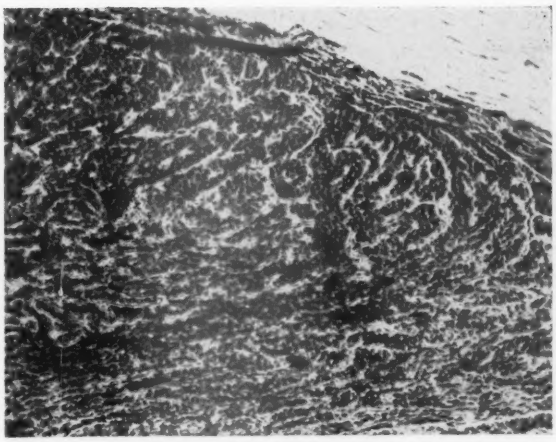

Fig. 2.—Magnification 100 x. Adenoma of the parotis.

cases one could speak of an "adenoma" of the parotid gland. An example follows:

A woman, aged 53, developed a swelling before the right ear 5 years earlier, which had gradually grown to the size of a walnut. She had no further complaints. The pathologico-anatomist's diagnosis was at the time: mixed tumor of the parotid gland. It is a tumor consisting of strands and alveoli of fairly small cubical or polygonal cells with a chromatinic nucleus, divided by thin, vasculated stroma showing hyaline degeneration in some places, but not in others (Fig. 2). The strands consist of two or more rows of cells. The cells show great regularity, mitosis is hardly ever found. The tumor is well capsulated. In a few places in the tumor fine oncocytes (very large vesiculiform cells) are found. As has been said before, oncocytes are also met with in the adenoma of the bronchus.

B. The following considerations are made for the assumption that it is probable that the adenoma of the bronchus has its origin in the mucosal glands. A transition of the covering epithelium into the tissue of the tumor is never seen. On the other hand it is fairly often seen that a part of the tumor consists of glandular ducts. Other authors, Holinger among them, have also described this. An example is given in Fig. 3 (Figs. 7 and 8 are of the same patient). In this section it can be seen that in the epithelial tumor obvious glandular ducts have been formed with a small empty lumen. These ducts are divided from each other by a row of cells of connective

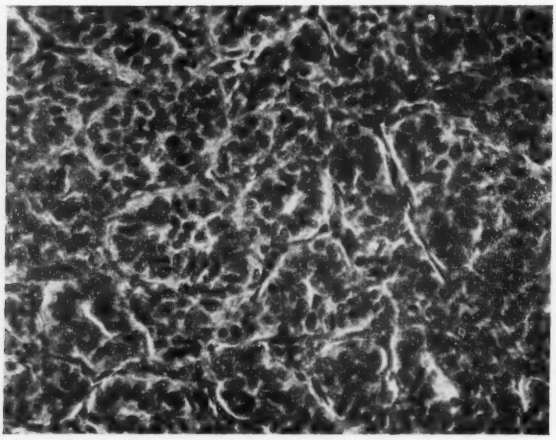

Fig. 3.—Magnification 275 x.

tissue, forming together a basement membrane, as it were. Sometimes the lumen is absent, in that case the ducts, consisting of cylindric epithelium, are solid.

We were given a strong argument by the following case, in which the tumor partly had the characteristic appearance of an adenoma of the bronchus, but in which the tumor cells had in other parts secreted a mucous excretion, accumulated as well inside as outside the cells. The patient was a 22 year old woman who had been treated for so-called tuberculous pleurisy during two years. She had atelectasis of a large part of the right lower lobe, caused by an obstruction in the lower lobe bronchus below the branching off of the apical branch. Bronchoscopy revealed a smooth red tumor.

The tumor partly consists of small solid alveoli of angular cells with small circular nuclei. Between these alveoli a capillary stroma is visible. In this part the tumor gives the characteristic picture of adenoma of the bronchus. In the larger part of the tumor, however, the picture is changed, owing to the fact that apparently the parenchymal cells produce a secretion, that accumulates as well inside as outside the cells in small and large lumps (Fig. 4). Here and there it even forms large gaps. The epithelial cells are nowhere arranged in cylinders.

C. In the trachea and in the bronchi real cylindromas occur, differing in nothing from those occurring in the salivary glands.

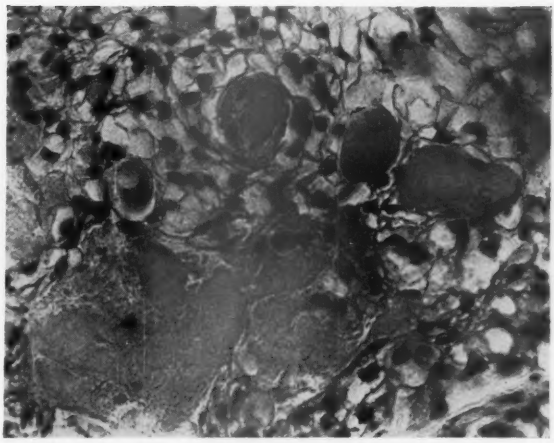

Fig. 4.—Magnification 275 x. Adenoma with secretion.

These cylindromas very obviously are of a less benignant character than adenoma, in the clinic one does well always to consider these tumors as malignant. This is also the opinion of Jackson, Holinger and many other bronchologists. In the literature a great many cases are to be found described as adenomas, but of which the microscopic picture clearly shows a cylindroma. This also explains for a considerable part, why some adenomas began to show malignant characteristics, which gave birth to the conception of a low grade carcinoma. According to us this view does not hold good for adenoma, but it generally does apply to cylindroma.

It remains a complete mystery why the cylindroma is preferably localized in the trachea and the adenoma in the bronchi. We saw two cylindromas of the trachea: The first, in a woman, aged 72, who had the cylindroma of the trachea removed surgically. After three years there was a recurrence which was also removed by tracheotomy. Half a year later she died from an intercurrent disease. The second, a man, aged 32, who had probably had the tumor for 3 years, quickly died in the clinic after violent hemoptyses. The tumor was situated in the lower part of the trachea and around the left main bronchus, which was almost completely occluded with atelectasis and bronchiectasis of the left lung. Obvious metastases were found in the mediastinal lymph nodes, not in other organs. The walls of the trachea and the left main bronchus were completely infiltrated.

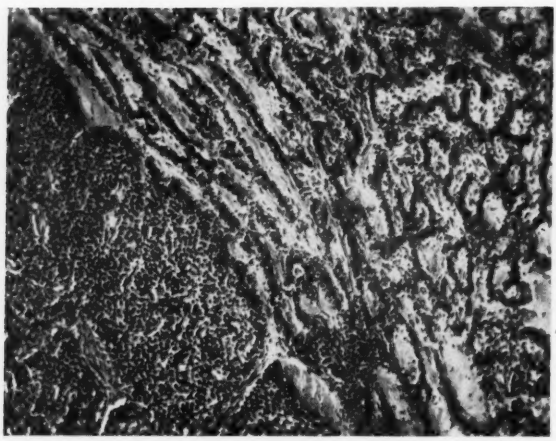

Fig. 5.—Tumor with an adenomatous and cylindromatous part. 100 x.

Peribronchial extension was seen a few times in our cases of adenoma of the bronchus, but metastases were never seen.

The third case of a tumor of the trachea was in a 38 year old man. He had been troubled for half a year by an increasing inspiratory stridor, caused by a smooth tumor in the lower half of the trachea. This tumor disappeared by means of irradiation. When the patient died nine months later from a carcinoma of the prostate, the post mortem examination revealed not a trace of the tumor in the trachea. Microscopically the tumor presented great difficulties. The pathologico-anatomist diagnosed it adenoma, but various sections were suggestive of cylindroma. As is known these tumors are as a rule very slightly radiosensitive.

D. Just now we discussed a tumor of which it was difficult to determine whether it should be called an adenoma or a cylindroma. There is, indeed, a close relationship between the adenoma and the cylindroma. This is obvious from the following fact: In three of our cases of adenoma of the bronchus a part of the tumor proved to be an obvious adenoma whereas another part showed all the characteristics of a cylindroma. Fig. 5 shows a microscopic section of one of these cases.

This patient was a 31 year old man, who had had hemoptyses since the age of eight, which had grown very severe during the last few years. On the section of Fig. 5 the border-line of the adenoma-

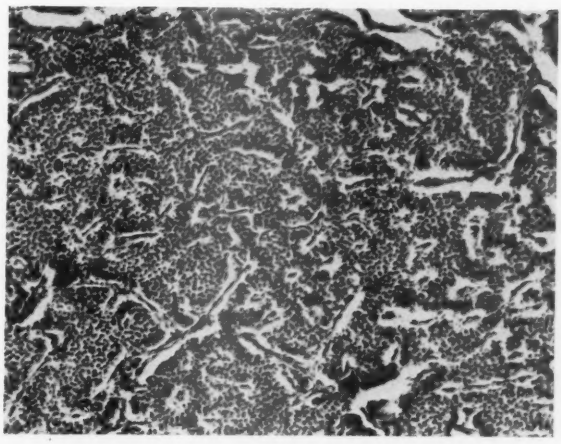

Fig. 6.—Adenomatous part of the tumor. 100 x.

tous and the cylindromatous parts is to be seen. In the left adenomatous part broad solid strands of cylindric cells are seen. In the right cylindromatous part the mesenchymal component prevails. In many places the connective tissue shows hyaline degeneration. There are fine, solid epithelial strands, composed of dark nuclei, the margins of the cells are vague. Mitosis hardly ever occurs, at the edges of the tumor there is no infiltrative growth. A second case follows below.

Figs. 6 and 7 show microscopic sections of the same tumor as Fig. 3. They are made from an adenoma of the bronchus of a 32 year old woman, who had been troubled with a productive cough and hemoptysis. A round, uneven tumor was situated at the beginning of the left lower lobe bronchus with peribronchial extension. There was atelectasis and bronchiectasis of the left lower lobe. The patient died during the beginning of the thoracotomy.

Fig. 8 shows the specimen obtained at autopsy (Prof. Vos). The chestnut-sized tumor in the left lower lobe bronchus is clearly visible. There is induration and bronchiectasis in the left lower lobe. The tumor has completely grown through the posterior wall of the lower lobe bronchus. Towards the lung, however, the tumor is completely bordered by a thin layer of connective tissue. As we can see in Fig. 6 the larger part of the tumor consists of polygonal

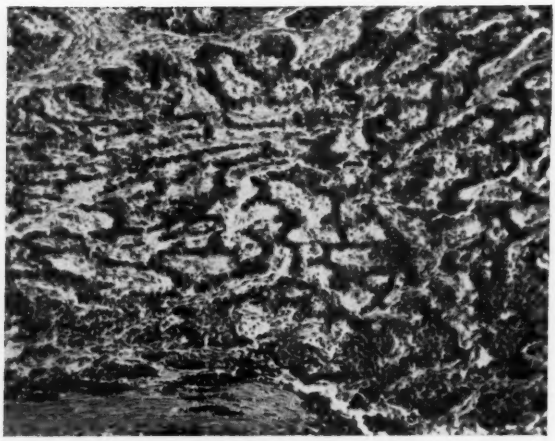

Fig. 7.—Same tumor as Fig. 6. Cylindromatous part. 114 x.

cells lying in smaller and larger solid sheets, imperfectly divided by thin strands of stroma. In some places the epithelium lies in garlands. Mitosis hardly occurs.

Fig. 7 shows quite another part of the tumor. Here the epithelium lies in thinner garlands, usually the thickness of a few rows of cells. The stroma between these cell-beams is swollen and hyalinized, so that a network of cell-beams results amid largely amorphous stroma, which is stained pink with eosine. Obviously, therefore, the structure of a cylindroma.

Until now we had not seen patients having a tumor of the bronchus, which should wholly be considered as a cylindroma. As has been said before, we only saw three adenomas of the bronchus parts of which were cylindromatous.

In tumors of the salivary glands it also fairly often occurs that part of the tumor shows an adenomatous structure, whereas another part shows a cylindromatous structure. The same applies to the palatal tumors originating in the seromucous glands. We removed a tumor the size of a pigeon's egg from the hard palate of a 65 year old woman. Part of it was an obvious cylindroma, another part looked like an adenoma of the bronchus.

E. The clinical course teaches us that the adenomas of the bronchus like the mixed tumors are on the border-line of malignancy and non-malignancy. Both show a slow, locally circumscribed

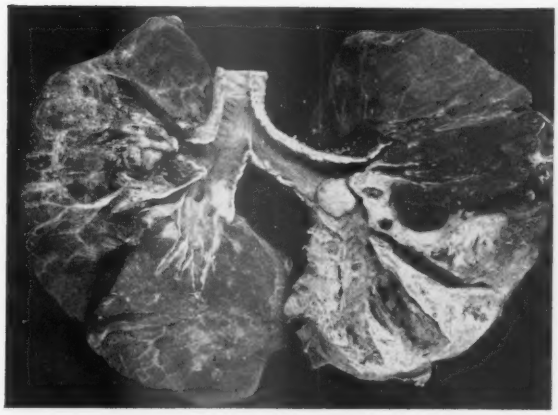

Fig. 8.—Autopsy preparation. Adenoma in left lower lobe bronchus.

growth without metastasis, whereas the not completely benign character is revealed in a certain power of infiltration. The mixed tumor having had a benignant character for years, may suddenly grow quickly, breaking through its capsule and even causing metastasis. Various observations (Mallory,[18] Womack and Graham,[5] Adam, Steiner and Block,[19] Chamberlain and Gordon,[20] Alexander,[3] Vismans[21]) show that this may also exceptionally happen to the adenoma of the bronchus.

THERAPY

Our conception of the adenoma of the bronchus gives important indications concerning its therapy. It is counted among the benignant tumors on the border-line of malignancy and as belonging to the parabuccal mixed tumors, it cannot be completely trusted. But on the whole in a specific case it is hardly necessary to take into account the possibility of malignancy, that is, that the tumor will be the direct cause of death. Things are quite different, of course, as concerns the indirect results: the anomalies in the part of the lung obstructed by the bronchostenosis. At any rate we cannot agree as do Jackson and Holinger among others, with some surgeons, who, considering the tumors as malignant, perform lobectomy or pneumonectomy on principle. It should be decided for every patient which therapy is best. Important in this respect are the localization and the extent of the tumor, and also the patient's age and social circumstances. With a correct indication bronchoscopy as well as surgery, may yield excellent results.

Fig. 9.—Dorsoventral bronchogram. Adenoma at arrow in left main bronchus.

Suitable for bronchoscopy are the polypous tumors growing in the lumen of the bronchus. For their removal we use a double curet and electrocoagulation by means of a biterminal electrode, which has little penetrating power. With two patients we succeeded in removing the tumor by scraping it out with the end of the tube as has also been suggested by Clerf.[22]

Twelve of our patients were treated with bronchoscopic therapy exclusively. This resulted in recoveries of 24, 14, 9 and 5 years' duration respectively. Some patients continue under regular treatment. In others the condition has considerably improved. A few of them are troubled with repeated recurrences. We proposed operation, but they refused.

Fig. 9 is a bronchogram of a 30 year old man who had coughed for three years and had had hemoptysis. He was treated for tuberculosis. It was a characteristic adenoma.

Fig. 1 shows a microscopic section of it. On the bronchogram the smooth tumor in the left main bronchus is clearly visible. There

Fig. 10.—Dorsoventral bronchogram. Stop in stem bronchus.

is bronchiectasis of the lower lobe. The patient has been in excellent condition for 24 years after bronchoscopic removal of the tumor. In this case this was done by first disenganging the tumor with the end of the tube.

Figs. 10 and 11 are the bronchograms of a 33 year old woman. She had had a productive cough for six months. A triangular shadow was visible in the lower part of the right side, characteristic of the falling out of one or two lobes. On the bronchogram of Fig. 10 a complete occlusion of the right stem bronchus is visible. The obstruction has a smooth margin, as it should have in cases of adenoma. Bronchoscopy showed a smooth tumor. Biopsy revealed an adenoma. In five stages the smooth round tumor was completely removed. She has been free from recurrence for 5 years. Fig. 11 shows the bronchogram after the removal of the tumor. It is clearly visible, that the lumen of the right stem bronchus is completely free again. As is always the case bronchiectasis has developed in the right lower and middle lobe.

Fig. 11.—Same patient as Fig. 10 after removal of tumor.

In other cases operation is immediately indicated. Fig. 12 shows the lateral bronchogram of a man, aged 31, who had for many years been subject to serious hemoptyses. A large smooth tumor was found in the lower lobe. Fig. 3 is a microscopic section of it. The bronchogram, Fig. 12, is a great exception. We see a very large tumor, which has considerably dilated the lower lobe bronchus, the lipiodol has accumulated on top of it and covers the tumor like a hat. A picture like this in which a slow growth has caused enormous dilatation of the bronchus is characteristic of a benignant tumor. Eerland successfully performed lobectomy of the middle and lower lobe. Fig. 13 shows the specimen. It clearly shows the large tumor and the considerable dilatation of the lower lobe bronchus. In the section, Fig. 14, the extent of the tumor is more obvious still. The patient has been in excellent condition for nine years.

Lobectomy or pneumonectomy was performed on five patients (Eerland). One of them died, four recovered. Of two patients the tumor had extended around the bronchus. This can be clearly revealed by means of planigraphy.

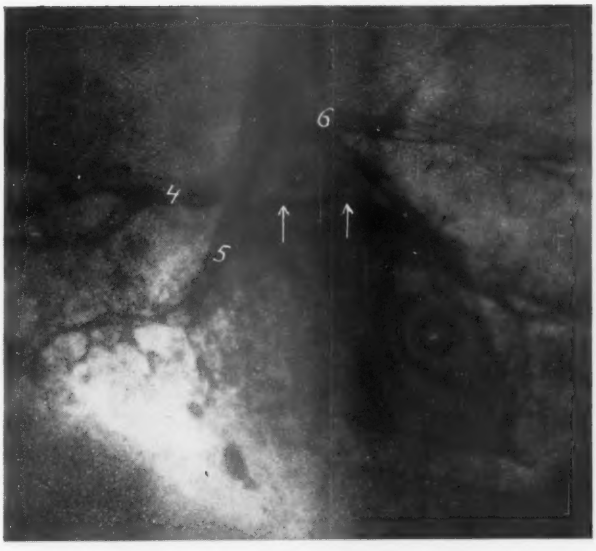

Fig. 12.—Lateral bronchogram, right side. Enormous adeno-cylindroma lower lobe bronchus with strong dilatation of the bronchus. 4 and 5, segmental bronchi of middle lobe; 6, apical of lower lobe.

Another indication for surgical treatment is deviation from the normal picture of the adenoma and certainly the presence of cylindromatous parts.

As was remarked above the patient's age and social circumstances are of great importance in determining the therapy to be applied. After bronchoscopic treatment the patient must for a very long time remain under supervision, bronchoscopy being performed at regular intervals. For many people this is disagreeable. For this reason operation was at once proposed to two young women aged 21 and 24 on whom lobectomy was successfully performed.

On the other hand we have treated for five years a woman who is now 64 years old. She had atelectasis of the left lower lobe. Fig. 15 shows the dorsoventral bronchogram. There is an obstruction in the left lower lobe bronchus. Bronchoscopy revealed a smooth red tumor, shown by biopsy to be a typical adenoma. The tumor was removed in some stages. Fig. 16 shows the result. The lower lobe bronchus is completely free. The origin of the tumor probably lies in the apical branch of the lower lobe. Again and again a tumor

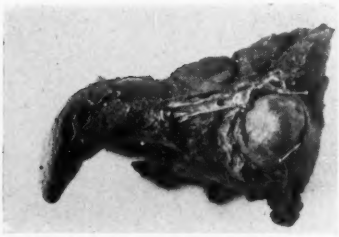

Fig. 13.—Operation preparation of the same patient as Fig. 12 seen from above. *a*, middle lobe bronchus.

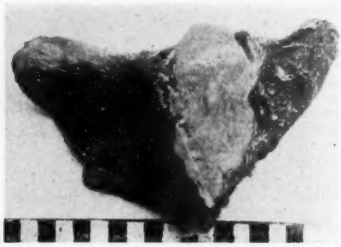

Fig. 14.—Section of the same tumor as Fig. 13.

appears from this place. This is removed every few months. Planigrams show an extension of the tumor into the apical segment. We proposed an operation but the patient refused. We did not press her any further as she is in excellent condition. The bronchogram of Fig. 16 shows that bronchiectasis has developed in the lower lobe, but the patient is but slightly troubled by it. The discharging bronchus, however, must be kept free. Even if bronchoscopic treatment did not effect complete recovery in this case, it remains, just as in other cases, of the greatest importance.

SUMMARY

At the Groningen clinic 17 patients suffering from adenoma of the bronchus and 3 patients having a tumor in the trachea (2 cylindromas and 1 adenoma) were treated. The greater part of these adenomas shows a characteristic microscopic picture. Some particulars are given. Part of the tumor may be a cylindroma.

Fig. 15.—Dorsoventral bronchogram. Stop in left lower lobe bronchus.

Two points are discussed more extensively. 1. What kind of tumor is the so-called adenoma of the bronchus. Our point of view is, that this epithelial tumor is a special localization of the parabuccal mixed tumor, originating from the bronchial glands. Various observations backing up this idea are mentioned. 2. For the therapy no rigid rule can be given. For every case various factors must be taken into account, e.g. the patient's age, the localization and the extent of the tumor, the microscopic picture, etc. Both bronchoscopy and surgery may yield excellent results, as was also stated in the Groningen clinics.

ACAD. ZIEKENHAUS, AFDELING KEEL-, NEUS-,
EN OORHEELKUNDE.

Fig. 16.—Same patient as Fig. 15 after treatment.

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XXIX

THE SURGICAL TREATMENT OF MÉNIÈRE'S DISEASE EXPERIMENTAL AND CLINICAL INVESTIGATIONS

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The usefulness of operations on the labyrinth for the relief of vertigo in true Ménière's disease is at present limited to cases with unilateral labyrinthine involvement and, perhaps with rare exceptions, to those without usable hearing in the affected ear.

The indications for operative treatment could, however, be considerably broadened if a method could be found which destroys the vestibular function or at least enough of it to eliminate the vertigo and at the same time preserve or even improve the hearing. The indications would then also include the by no means rare bilateral involvement of the labyrinth and the frequent cases with still usable hearing in the affected ear.

The possibility that this aim could be achieved is suggested by the fact that after coagulation of the labyrinth (Day) the hearing is not invariably lost, but in some rare instances is retained at preoperative level or even improved beyond it. It is, however, at present impossible to know beforehand in which cases this result can be expected.

The findings in the one case which was examined histologically after coagulation by Day and Lindsay and which incidentally showed considerable postoperative improvement in hearing are not very revealing.

An advanced degree of endolymphatic hydrops was present in a man, sixty-one years old, on whom a coagulation had been performed five years before death. The utricle was almost entirely destroyed and the macula no longer present. The lumen of the hori-

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zontal and superior vertical canals, including the ampullae, was filled with connective tissue and new bone. The ampulla of the posterior vertical canal showed distortion of the wall. The cochlear duct was dilated to such a degree that the vestibular scala was obliterated throughout almost its full extent.

There were marked degenerative changes of a peculiar character in the organ of Corti in the basal and most of the middle coil and atrophy of the stria vascularis throughout the cochlea.

It is difficult to decide how much of the cochlear changes in this patient could be attributed to the labyrinthine hydrops, to a postoperative serous labyrinthitis, or to postmortem changes. The dilatation of the cochlear duct was unquestionably due to the hydrops. The detachment of the tectorial membrane and its overgrowth by epithelial cells from the neighborhood, seen in the basal and middle coil, seems a characteristic feature of a healed serous labyrinthitis. Although partial atrophy of the stria vascularis has sometimes been seen in hydrops, the marked atrophy of the stria in all cochlear turns is more likely to be the sequel of a healed diffuse serous labyrinthitis. In addition, the presence of moderate postmortem changes, as shown by comparison with the other side, makes interpretation of the findings still more difficult.

It can safely be said that coagulation in this patient was followed by a diffuse serous labyrinthitis. Although it is well known that the hearing in some cases of healed serous labyrinthitis returns to the previous level, it is nevertheless surprising to see that such marked cochlear changes were still compatible with relatively good hearing.

Results of animal experiments are, unfortunately, not much more illuminating than the findings in this one human specimen that has come to postmortem examination.

Proctor experimented in rabbits before penicillin was available and found that instrumentation within the vestibule in an attempt to rupture or injure the utricle, resulted in extensive fibrosis of the perilymphatic spaces and varying degrees of hydrops and degeneration of sensory organs.

Schlander performed coagulation in guinea pigs and rabbits, also without the postoperative use of penicillin. Within six hours there were hemorrhages into the perilymphatic spaces and within twenty-four hours diffuse serofibrinous labyrinthitis of varying intensity terminating in complete destruction of the membranous parts of the inner ear. Schlander feels that destruction of the labyrinth

does not depend so much on the intensity of the coagulating current as on the operative trauma (opening of the lateral semicircular canal and introduction of the metal needle into the vestibule).

Schall and Rambo performed coagulation in monkeys, again without the postoperative use of antibiotics. When an adequate coagulating current was used the membranous labyrinth in the vestibule and the semicircular canals was consistently destroyed. Coagulation was followed by serous and soon thereafter by serofibrinous exudation into the vestibule and the semicircular canals. The exudate was gradually organized. When the intensity of the coagulating current was smaller, the membranous labyrinth remained unchanged, and there was only a limited amount of serofibrinous exudate in the vestibule. Changes in the cochlea varied from absence of any damage to serous and serofibrinous labyrinthitis.

The authors concluded that the damage to the membranous labyrinth of the vestibular portion, where optimum current is used, is complete and predictable. There was, however, in their opinion, no significant pattern in their series as to the amount of damage to the cochlea, either in relation to the time elapsed since the operation or the amount of coagulating current used.

Lindsay, using penicillin postoperatively, also operated on monkeys. He performed coagulation of the ampulla of the horizontal canal, coagulation of all membranous canals at maximum distance from the vestibule, injury to the nerves leading to the horizontal canal ampulla and to the utricle, detachment of the otolithic membrane of the utricle, and use of a coagulating current which was not strong enough to cause bubbling or visible changes but sufficiently strong to produce a facial nerve stimulus. Histologically in all cases evidence of injury to the vestibular apparatus was demonstrable; in no case, however, did the injury result in any extensive change or fibrosis in the perilymphatic space of the vestibule. None of the procedures resulted in any histologic change in the auditory apparatus nor in any case was there more than a minimal amount of fibrous tissue in the perilymphatic cistern. The histologic findings in these ears failed to provide an explanation for the profound loss of hearing in humans in whom coagulation procedure had been limited to canals or their ampullae only.

A review of these changes shows a discrepancy between the results of Lindsay, who reported complete lack of recognizable pathologic changes in the cochlea and no fibrosis or only a minimum in the perilymphatic space of the vestibule, and the statements of other authors who found much more extensive changes in experimental animals and in man.

It is conceivable that the serofibrinous labyrinthitis noted in experimental animals in which no penicillin was used postoperatively was not simply an aseptic inflammation but a mild infection spreading from the operative cavity into the labyrinth. It should be noted that the cochlear changes in the human, although extensive, were regarded as sequels to a serous, and not serofibrinous, labyrinthitis.

In order to get additional information about the histologic changes following intralabyrinthine surgery, experiments were carried out in six Rhesus monkeys.

All twelve ears were operated upon, one ear being done at one time, the other ear being operated the following week. The operations were done with a strictly aseptic surgical technic and, following operation, the monkeys were given daily intramuscular injections of penicillin (300,000 units in oil) for one week. Nembutal was used as anesthetic, 30 mg per kilogram body weight given intraperitoneally.

Through a postauricular approach the mastoid was entered and the lateral semicircular canal exposed. A fenestra was then made into the anteriormost portion of the canal near its ampullated end and the membranous canal examined with the help of a dissecting microscope (magnification 10 x).

In one group of cases a fine needle was introduced through the fenestra into the vestibule and the contents coagulated. A "Hyfrecator" was used in all cases and the intensity of the coagulating current varied in the different cases. Coagulation was accompanied in all cases by contraction of the facial muscles and in most of them by bubbling of the perilymph. The fenestra was then filled with bone dust.

In another group the fenestra was plugged with bone chips in an attempt to bring about a circumscribed obliteration of the lateral semicircular canal, but no coagulation was done.

Table I gives the necessary data on the operations.

Histologic examination of the nine ears in which coagulation had been used showed the following:

Monkey 1, *right side.* The vestibule had been inadvertently opened instead of the lateral semicircular canal. There was an acute purulent infection of the middle ear spreading through the vestibular opening into the labyrinth and causing a diffuse purulent-necrotizing labyrinthitis.

Monkey 1, *left side.* The fenestra contained necrotic masses and small bone chips. The membranous canal was unrecognizable

TABLE I

MONKEY NUMBER	SIDE	DIAL SETTING OF HYFRECATOR	NUMBER OF DAYS ELAPSED FROM TIME OF OPERATION TO DEATH OF ANIMAL
GROUP ONE: COAGULATION			
1	right	low 2	8
1	left	low 2	1
2	right	high 1	38
2	left	high 1	31
3	right	low 5	38
3	left	low 2	31
4	right	low 5	68
4	left	low 5	64
5	right	low 5	94
GROUP TWO: PLUGGING OF THE CANAL			
5	left	bone chip	59
6	right	bone chip	66
6	left	bone chip	59

for a distance of 0.75 mm from the margins of the fenestra. Directly from there on, it became clearly outlined and showed a normal structure. No definite pathologic changes were found in the other parts of the inner ear, including the vestibule and cochlea. The organ of Corti showed marked postmortem changes.

In the other seven ears, the operative cavity in the mastoid and antrum was filled with scar tissue extending into the fistula and from there for a short distance (0.5-1.0 mm) towards both ends of the canal. Embedded in this scar tissue, which showed no evidence of infection, were small bone chips around which new formation of weblike fibril bone in net-like arrangement could be seen. The membranous canal as a rule was not visible in this area, but sometimes small hyaline masses were observed which could represent remnants of the canal walls. Beyond this area, the perilymphatic as well as the endolymphatic spaces, including the maculae, cristae, and the contents of the cochlear duct, showed no pathologic changes in the following ears: Monkey 3, right and left side; monkey 4, right side; monkey 5, right side. In monkey 4 nothing could be said about the condition of the inner ear on the left side because of faulty em-

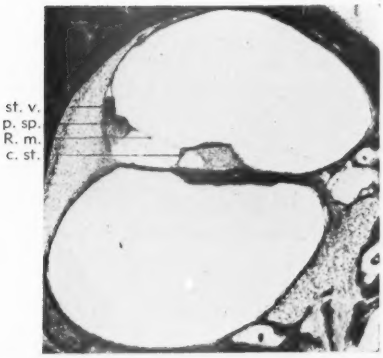

Fig. 1.—Monkey 2, right side. Complete collapse of Reissner's membrane. *c. st.*, cellular string extending from the remnants of the collapsed organ of Corti to the tip of the crista spiralis. *p. sp.*, prominentia spiralis. *R. m.*, Reissner's membrane. *st. v.*, stria vascularis.

bedding. The remaining two ears shall be described in somewhat greated detail.

Monkey 2, *left side.* There was more extensive scar tissue in the lateral semicircular canal than in the other specimens and it almost reached the crista ampullaris. The latter was covered by one layer of low epithelium and the cupula was missing. The two other cristae, the utricle, and the structures within the cochlear duct showed moderate postmortem changes but no recognizable pathologic condition.

Monkey 2, *right side.* The scar tissue filling the lumen of the lateral canal extended into the adjacent parts of the crista ampullaris. The latter showed fibrosis of its matrix and was covered with a single layer of low epithelium. The cupula was absent. Utricle, saccule, and the two other semicircular canals appeared normal.

In the cochlea, there was a small amount of blood in the scala vestibuli of the upper half of the basal turn. Reissner's membrane was in normal position in some places, completely collapsed in others (Fig. 1). In still others it was retracted in the central parts and adherent to the remnants of the stria vascularis and the prominentia spiralis.

Corti's organ was reduced to a small mound of undifferentiated cells or even completely missing. The tectorial membrane in those places where Reissner's membrane was not collapsed was reflected

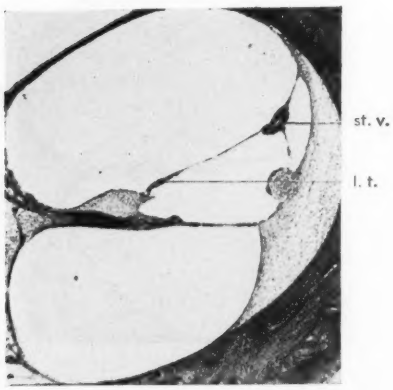

Fig. 2.—Monkey 2, right side. Detachment of the stria vascularis from the underlying tissue (fixation-artefact). *l. t.*, Lamina tectoria, adherent to Reissner's membrane. *st. v.*, detached and folded stria vascularis adherent to Reissner's membrane, pulling along a string of tissue.

upward and adherent to the latter (Fig. 2). External and internal spiral sulcus were covered with flat epithelium. In several places a string of epithelial cells could be seen extending from the collapsed remnants of Corti's organ to the tip of the crista spiralis, thereby traversing the internal spiral sulcus (Fig. 1). The stria vascularis in many places was detached from the underlying tissue and adherent to Reissner's membrane (Fig. 2). In others, it was detached in its upper parts only, folded in upon itself and thus shifted towards the prominentia spiralis. In these areas Reissner's membrane was, as just mentioned, retracted in its central parts and adherent to the prominentia.

The cells of the spiral ganglion showed no pathologic changes.

Comment. The atrophic changes in the crista ampullaris of the lateral semicircular canal on the left side were possibly caused by the action of the coagulating current.

On the right side, the changes in the crista ampullaris of the lateral semicircular canal were also most probably caused by the coagulating current either alone or in conjunction with the ingrowth of scar tissue into the matrix of the crista. The cochlear changes seemed to represent a mixture of true pathologic changes (residua after a serous labyrinthitis) together with postmortem changes and artefacts.

The pathologic changes were considered to be the extensive degeneration of the organ of Corti, the formation of epithelial strings between the organ of Corti and crista spiralis, the flatness of the epithelial lining of the spiral sulci, some of the changes in the shape and position of the stria vascularis and the partial collapse of Reissner's membrane. An unquestionable artefact developing during the process of fixation and embedding was the complete detachment of the stria in large areas from the underlying tissue. It occurred when the collapsed membrane of Reissner, on returning to its original position, pulled along the adherent stria.

A review of the findings shows that in the cases in which a coagulating current of lower intensity was used the changes were confined to the area of the fenestra and its immediate vicinity. When the intensity of the current was somewhat higher atrophy of the crista ampullaris was observed, sometimes combined with residua of a serous labyrinthitis. The atrophy of the crista could be the direct effect of the coagulating current, the serous labyrinthitis the result of a chemical irritation following a more extensive coagulation necrosis of the labyrinthine contents.

One possible way of avoiding serous labyrinthitis seemed to be a reduction in the intensity of the coagulating current. Thus in one patient to be operated upon for Ménière's disease the dial of the Bovie coagulator was turned down so far that the tip of the needle, when touching fibers of the temporalis muscle, produced a small area of coagulation measuring only 1-2 mm in diameter.

REPORT OF CASES

CASE 1.—Charles R., 43 years. Patient had been suffering from incapacitating attacks of vertigo for one and a half years with decrease in hearing and tinnitus in the right ear. The audiogram showed a more uniform hearing loss in the right ear, averaging 60-70 decibels with normal hearing in the left ear. The vestibular responses were within normal limits in both ears.

On December 11, 1950, coagulation of the right labyrinth was performed. After exposing and opening the lateral semicircular canal, the needle was introduced into the vestibule and its contents coagulated three times. During coagulation, there was marked twitching of the face, but no bubbling of the perilymph.

The following day, there was horizontal-rotatory nystagmus to the left and complete loss of hearing which remained permanent.

Ten days after operation nystagmus of 1° was present. The Hallpike tests showed the following:

	30°	44°
Left side	0 sec.	165 sec.
Right side	115 sec.	0 sec.

There was no complete loss of function as is usual after coagulation, but only a preponderance to the left.

Four weks after operation, the nystagmus had almost subsided; Hallpike tests gave the following result:

	30°	44°
Left side	80 seconds	130 seconds
Right side	195 seconds	30 seconds

In accordance with the subsidence of the spontaneous nystagmus, the preponderance was now less marked.

One week later, the spontaneous nystagmus had completely disappeared. The patient has had no attack of true vertigo since the operation, but complains of "lightheadedness."

Comment. Although the current in this case was not strong enough to coagulate the labyrinthine contents, the intervention was nevertheless followed by a labyrinthitis which destroyed the hearing completely. If one compares the outcome in this case with the marked hearing improvement in the case of Day and Lindsay in which there was histologic evidence of extensive coagulation of the labyrinthine contents, one comes to the conclusion that reducing the intensity of the coagulating current is not an effective way of achieving an elimination of the vestibular function with preservation of the hearing.

At least part of the vestibular function might return even after a stronger coagulation of the labyrinth and might be accompanied by a return of vestibular symptoms. This can be seen from the following observation.

Case 2.—F. D., sixty-one years of age. Patient had a Portmann operation for right-sided labyrinthine hydrops on June 10, 1948. Following the operation, he was free of complaints for nine months. Then the attacks recurred with increasing intensity. On April 7, 1949, a coagulation was done. During coagulation, twitching of the face and bubble formation in the perilymph was noted. After the

second operation, the hearing was completely and permanently lost. The patient continued to have slight attacks of dizziness for a while, followed by attacks of "lightheadedness." Hallpike tests taken on August 9, 1949, showed the following:

	30°	44°
Left side	90 sec.	110 sec.
Right side	0 sec.	0 sec.

After instillation of 10 cc of ice water into the right ear, there was nystagmus of short duration to the left. The results indicate a marked hypofunction of the left labyrinth, but no complete loss of function.

Hallpike tests taken seven and a half months later on March 28, 1950, gave the following result:

	30°	44°
Left side	105 sec.	139 sec.
Right side	0 sec.	100 sec.

There is a marked return of function as compared with the preceding test, but still a hypofunction of the right labyrinth.

Comment. The return of vestibular function together with some of the patient's complaints shows the importance of using sufficiently strong coagulation currents. Since the actual intensity of the current within the vestibule depends on many variable factors, no definite, optimal dial settings on the Bovie unit can be given. Experience, only, will show which intensity should be used in a given case. If the current is too strong, temporary facial paralysis might ensue; this happened in one patient operated in our department.[1]

Another attempt to eliminate the vertigo but to preserve the hearing took its origin from the claim of Cawthorne, Fitzgerald and Hallpike, that in about 60 per cent of the cases of Ménière's disease the vestibular tests reveal a lesion of the lateral semicircular canal without utricular involvement; in about 20 per cent utricular paresis alone, and in another 20 per cent utricular paresis together with paresis of the lateral semicircular canal. It was felt that if this claim is correct, obliteration of the lateral semicircular canal alone or together with destruction of the crista ampullaris might be sufficient to eliminate the attacks of dizziness, at least in the cases where the vestibular tests indicate a canal paresis.

TABLE II.

LEFT EAR

DATE	128	256	512	1024	2048	4096	8192
1/9/48	40	50	55	50	35	25	20
1/12/48	20	20	25	20	10	15	15
1/14/48	20	25	25	15	10	10	5
1/15/48	15	25	15	15	5	10	10
1/19/48	operation						
1/27/48	not heard			----	----	----	----
1/30/48	55	65	75	75	65	80	75
2/4/48	55	70	90	90	75	75	75
2/6/48	not heard	80	80	70	50	65	65
5/13/48	60	65	70	70	65	70	75
11/12/48	50	60	65	65	50	65	65
3/14/49	50	55	55	65	55	50	60
7/5/50	55	60	70	65	55	75	not heard
12/26/50	45	45	55	65	65	65	80

(Loss in decibels)

Lempert, at a meeting of the American Academy of Ophthalmology and Otolaryngology in Chicago, October, 1949, made a preliminary report suggesting that by plugging the lateral semicircular canal attacks of dizziness were eliminated, at least for the time of observation, and the hearing preserved.

The *histological examination* of the three ears of the monkeys mentioned above where the fenestra was plugged with bone chips without coagulation of the labyrinthine contents (monkey 5, left side; monkey 6, both sides) showed that the changes in the fistula and adjacent areas were essentially the same as in the cases with coagulation. In one specimen (monkey 5, left side) remnants of the membranous canal, compressed by bone chips, were still visible. In the other two, no traces of the membranous canal were seen within the scar tissue. There were no pathologic changes in the cristae ampullares, the utricle, saccule, or the cochlea, only certain postmortem changes.

These findings gave further encouragement to the idea of plugging the lateral semicircular canal in cases of Ménière's disease in man. This operation was done in three patients.

TABLE III.

VESTIBULAR TESTS (Hallpike)

	30°		44°	
DATE	LEFT SIDE	RIGHT SIDE	LEFT SIDE	RIGHT SIDE
1/9/48	145 sec.	135 sec.	120 sec.	134 sec.
1/19/48	operation			
1/30/48	0 sec.	140 sec.	0 sec.	152 sec.
11/12/48	some jerks	104 sec.	some jerks	125 sec.
3/14/49	0 sec.	125 sec.	0 sec.	135 sec.
	Response left after 25 cc of ice water			
6/28/50	Dizzy spell			
7/6/50	0 sec.	125 sec.	100 sec.	135 sec.
	Response left after 10 cc of ice water			
12/26/50	No change from 7/6/50			

CASE 3.—B. V., forty years old. The patient complained of intermittent buzzing in the left ear for the past three years, diminished hearing in the same ear, and attacks of vertigo for the past year. The attacks of vertigo persisted in spite of medical treatment. Hearing tests showed normal hearing in the right ear and reduced hearing of varying degree in the left ear (See Table II). The vestibular tests showed normal responses on both ears (See Table III).

On January 19, 1948, the left lateral semicircular canal was plugged with a bone chip by Dr. E. P. Fowler, Jr.

After the operation, the patient had a moderate degree of vertigo and horizontal rotatory nystagmus 1-2° to the right side, which subsided after a few days. An audiogram taken eight days after the operation showed complete loss of hearing; three days later some hearing had returned. During the following three years, the hearing showed fluctuations, but has been retained (See Table I). The buzzing did not disappear. The vestibular function on the operated ear was lost immediately after the operation, but ten months later there were the first signs of its return. It gradually improved, and the last test taken December 26, 1950, showed only a slight hypofunction on the operated side.

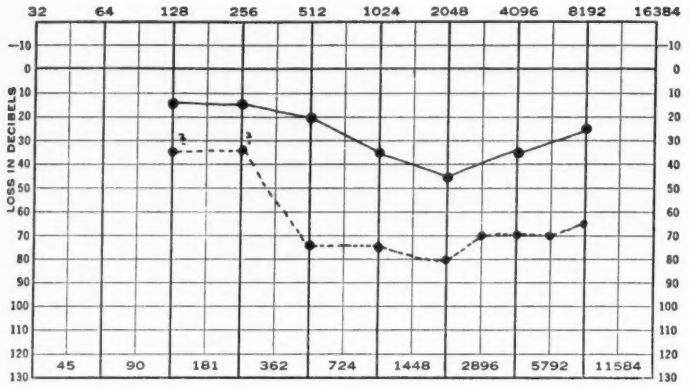

Fig. 3.—Audiogram, case 4.

The patient was without vertigo for two and a half years. He had one moderately severe spell in June, 1950; since that time, he has been free of vertigo.

Comment. This case shows that plugging of the canal may control the attacks of vertigo, although not as effectively as sufficiently strong coagulation. With this procedure some of the hearing was also depressed. The amount of hearing retained, however, is below the serviceable level. It is therefore of little practical use unless something happened to the better ear in which case a hearing aid could be worn.

CASE 4.—L. H., a woman of fifty-six years, complained of progressive deafness in the left ear and continuous ringing for two years, attacks of vertigo for one year which lately had become very frequent and unbearable. A hearing test taken on September 26, 1950, showed a moderate hearing loss on the left ear (see audiogram—Fig. 3); Hallpike tests showed the following:

	30°	44°
Left side	100 sec.	119 sec.
Right side	122 sec.	150 sec.

The figures are indicative of a slight relative hypofunction of the left labyrinth ("canal paresis").

Since all medical treatment had been completely unsuccessful, on October 2, 1950, the left horizontal semicircular canal was plugged with a bone chip near its ampullated end. The day following the

operation there was no nystagmus or dizziness. The next day there was slight vertigo and horizontal rotatory nystagmus 1° to both sides. After that, the patient remained completely free from vertigo. The ringing remained unchanged. Three days after the operation, the patient heard in the operated ear, words spoken at a distance of 30-40 cm, with the other ear masked with a noise box. Eight days after operation, the hearing was, however, completely lost. Three months after operation, the patient was still free of vertiginous attacks, but felt somewhat "lightheaded" at times. The tinnitus persisted. An audiogram taken on December 28, 1950, showed that some of the hearing had returned (see audiogram). The figures for the frequencies 128 and 256 represent evidently the perception of vibration and not real hearing and must, therefore, be disregarded.

Comment. In this case the vertigo was again controlled by plugging, at least for the relatively short period of observation. The hearing was completely lost temporarily, but some of it returned; it is, however, far below the serviceable level. The temporary loss of hearing is unquestionably due to a serous labyrinthitis; it is interesting to note that it occurred after the third postoperative day and not immediately after the operation. Similar observations were made by Schlander after coagulation. He found a loss of labyrinthine function five to seven days after coagulation, and came to the conclusion that it was not a direct effect of the coagulating current but the result of a postoperative serous or serofibrinous labyrinthitis.

Plugging of the horizontal canal, however, does not always succeed in eliminating the vertiginous attacks. This can be seen from the following observation.

CASE 5.—J. H., a man of forty-seven years, complained of reduced hearing in the right ear without ringing for many years, and attacks of vertigo of increasing intensity for three months. Medical treatment did not influence his vertigo and the patient was unable to work.

Hearing tests taken on July 17, 1950, and October 3, 1950, showed markedly reduced and fluctuating hearing in the right ear.

Vestibular tests (Hallpike) gave the following results.

	30°	44°
Left side	90 sec.	140 sec.
Right side	120 sec.	100 sec.

This was interpreted as nystagmus preponderance to the left side, indicating rightsided utricular paresis.

On October 9, 1950, the right horizontal canal was plugged with a bone chip. After the operation, the patient had slight vertigo with horizontal rotatory nystagmus to both sides for a few days; five days after operation, the patient was found to be completely deaf in the right ear.

Vestibular tests taken two weeks after operation showed complete loss of function in the operated ear.

A few days later, the attacks of vertigo recurred with full intensity. Vestibular tests taken on November 8, 1950, one month after operation, showed a partial return of function.

	30°	44°
Left side	129 sec.	155 sec.
Right side	0 sec.	145 sec.

Hearing tests again showed complete deafness in the right ear.

On November 10, 1950, a transtympanic labyrinthotomy, using Lempert's method, was performed.

Vestibular tests taken on December 5, 1950, twenty-five days after operation, showed complete loss of function for calorization as well as rotation. There was unsteadiness after the operation for a few weeks, but no more attacks of vertigo. Two months after the operation the patient was able to resume his work as a truck driver and since that time has been completely free of complaints.

Comment. In this case the attacks persisted after plugging the horizontal canal. The hearing was nevertheless completely lost. If one had waited for a longer period of time, some of it might have returned. Judging from the two preceding cases, it seems unlikely that enough of it would have come back to be of any practical use. The persistence of vertigo and the wish of the patient to return to work as soon as possible made any further waiting undesirable.

A review of these three cases shows that plugging of the horizontal semicircular canal may or may not eliminate the vertiginous attacks, no matter whether the vestibular findings indicate "utricular paresis" or "canal paresis." Even though done with the greatest precautions, with a strictly aseptic technique and adequate use of antibiotics, the plugging was always followed by a diffuse serous labyrinthitis, as manifested by the complete, though temporary, loss of auditory and vestibular functions. In two cases some of the hearing returned, but in both it was so far below the serviceable level that it was of very little if any practical use. The vestibular func-

tion returned, at least partially, in the two cases in which it was tested. This return of the vestibular function is undesirable since it may be accompanied by return of violent attacks of vertigo as in case 3 where the labyrinth had to be completely destroyed in a second operation.

In conclusion one can say, therefore, that plugging of the lateral semicircular canal is not an effective method for the surgical treatment of Ménière's disease. It is not a reliable procedure either for elimination of vertigo or for preservation of hearing at a serviceable level.

Under these circumstances other possibilities for a more successful surgical management of the disease should be investigated.

The great percentage of temporary successes after incision of the endolymphatic sac (Portmann) or tearing of the endolymphatic duct at the point of its emergence from the petrous pyramid (Woodman) shows the effectiveness of the drainage of the endolymphatic system. The reason for the eventual failure in nearly all the cases lies in the inability to secure a permanent patency of the drainage opening. The closure could possibly be prevented by placing the drainage opening into the labyrinth itself, by draining the endolymph into the perilymph instead of into the subarachnoid space. This could be effected by excision of a small piece of the lateral semicircular canal; it could be hoped that the flow of endolymph towards the perilymphatic space might keep the two openings in the membranous canal patent. The window in the lateral semicircular canal should be made into the vertex of its convexity, as far as possible away from the vestibule. In this way the danger of a postoperative serous labyrinthitis and its damaging effect on the hearing would be considerably reduced. This can be concluded from the observation of Putnam who found no change in hearing after opening the convexity of the superior vertical canal and coagulating its contents. The window in the bony canal should be closed with an inert, non-irritating material and great care should be taken to leave the width of the lumen of the canal unchanged.

Removal of the stellate ganglion has been reported as a promising treatment in Ménière's disease by several authors. In a number of cases of perception deafness with continuous ringing, we had the ganglion injected with novocaine and in some of them also with alcohol. In none of the cases, however, were the results satisfactory enough to justify an extirpation of the ganglion. Suboccipital cisternal puncture with removal of 40 cc of cerebrospinal fluid proved completely ineffective in two other cases.

In view of these poor results, we are still hesitant to try ganglionectomy as well as cisternal puncture in cases of Ménière's disease.

SUMMARY AND CONCLUSIONS

The reported histologic changes following coagulation of the labyrinth in a single case of Ménière's disease in man and in experimental animals are reviewed and the results of our own experiments in monkeys are given.

The vestibular portion of the labyrinth, due to its proximity, shows the main damage. The electric current itself or the heat created by it causes necrosis of certain parts of the membranous labyrinth. This is followed by secondary reparative changes in response to the tissue necrosis, by the ingrowth of organizing connective tissue, which might go far beyond the area of the original necrosis and fill out the lumina of the semicircular canals and the greater part of the vestibule. Later, bone might be formed within the connective tissue. The extent and degree of the changes within the vestibular portion seem to depend mainly upon the intensity of the electric current used, provided that no infection supervenes to complicate and confuse the picture. Thus, if the currents are weak, the changes are confined to the vicinity of the opening in the semicircular canal.

Interpretation of the changes in the cochlea is much more difficult. This is mainly due to the invariable postmortem changes in the organ of Corti and our inability, in many instances, to differentiate between these postmortem changes, fixation artefacts, and intravital changes which, although morphologically insignificant, might nevertheless cause a complete loss of function. The only thing which seems certain is that even without a supervening infection the coagulation necrosis is followed by a diffuse serous aseptic labyrinthitis. The degree of the remaining or returning cochlear function depends upon the extent to which the damage suffered by the cochlear structures from the labyrinthitis is permanent and irreversible.

No correlation could be found between the amount of this damage, the intensity of the coagulating current, or any other factors.

In an attempt to reduce the intensity of the postoperative serous labyrinthitis, the strength of the coagulating current was reduced in various degrees in two cases of Ménière's disease. The result, however, was unsatisfactory since the dizziness was not completely eliminated but the hearing was nevertheless completely lost.

Another attempt at overcoming the difficulties lay in plugging the membranous lateral semicircular canal without coagulation.

Experiments in monkeys showed that in these cases a circumscribed fibrosis developed around the obstructing bone chip with no definite changes in other parts of the labyrinth. The membranous canal was plugged in three cases of Ménière's disease. In two of them the vertiginous attacks were practically stopped and some of the hearing retained; in the third, the attacks continued unchecked and the hearing was completely lost. The amount of hearing retained in the first two cases was, however, too small to be of practical value.

Plugging of the lateral semicircular canal seems, therefore, not a reliable method either for elimination of the vertigo or preservation of the hearing at a serviceable level.

Our studies show that in the cases of Ménière's disease in which coagulation is indicated a strong current should be used and a postoperative infection prevented by use of antibiotics. The small size of the window and its location away from the ampulla might also reduce the amount of postoperative reaction. Any attempt to decrease the intensity of the coagulating current in order to preserve the hearing is useless and jeopardizes the elimination of the vertigo. In order to prevent damage to the facial nerve, excessively strong currents should also be avoided. In view of the many variable factors, the operator must be guided in the selection of the proper strength of the coagulating current by his personal experience and his familiarity with the method used.

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XXX

THE EFFECT OF DIHYDROSTREPTOMYCIN HYDROCHLORIDE AND SULFATE ON THE AUDITORY MECHANISM

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This is a report of a study made on 211 cases of tuberculosis. These patients were treated with dihydrostreptomycin to test its therapeutic and toxic effects as compared to regular streptomycin. Particular attention was paid to the vestibular and auditory mechanisms. The report covers a period of two and one half years.

The relation of streptomycin to the vestibular and auditory systems has been of considerable interest and importance to the otologist ever since Brown and Hinshaw[1] first reported an adverse effect on these systems in treating tuberculosis. Since then a great deal of study, some clinical and some animal research, has been done.

The important effect of streptomycin to the otologist is the reduction of sensitivity of the peripheral end organ of the vestibular system.

A demonstrable effect occurs in all cases treated over 14 days with 1 gram per day or more. The amount and permanency of this effect is directly related to the total dose of the drug. This effect definitely upsets the fine triangular balance existing between the visual, vestibular, and kinesthetic senses. Fortunately, however, the individual can compensate for the loss of one of these, but is seriously hampered if one of the two remaining senses is adversely influenced. Compensation proceeds much faster and more completely in the young than in the old. This is an important fact and should be considered before streptomycin is administered to the older patients for periods longer than 10 days. Such things as bad vision, diseases producing ataxia, and other locomotor dysfunctions should be taken into account also. In a previous unreported study on caloric reaction it was definitely shown that on doses of less than 1 gm per day for a period of 90 days there is a distinct lowering of sensitivity of

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the vestibular response to caloric tests, which returns to normal 12 to 20 weeks after treatment has been stopped.

About 18 months ago a new drug related to the streptomyces group called dihydrostreptomycin was produced.

On the basis of animal experimentation, this new streptomycin was said to be far less toxic than the old. In fact, it has proved to be less toxic to the vestibular apparatus, but far more toxic to the auditory mechanism.

This has been shown by a study of over 200 patients treated with dihydrostreptomycin hydrochloride. These tuberculosis patients were given from 1 to 3 gms per day for from one to six months. None had less than one month's treatment.

The original group treated comprised 61 patients. All received amorphous dihydrostreptomycin hydrochloride. All were studied in the following manner by the same observer:

All caloric tests were done after the method of Fitzgerald, Cawthorne and Hallpike[2] as modified by Glorig and Fowler.[3]

A common one-gallon thermos jug acting as a reservoir supplied water through a 30-inch rubber tube fitted with a glass tip tapered to a 3 or 4 mm outlet. About 6 inches from the outlet a bronchoscopic collection tube containing a thermometer was connected. This served for reading the temperature directly at the ear at all times before and during the test to assure a constantly maintained stimulus of a specified amount.

The complete FCH test uses water at two temperatures, 30° C. and 44° C. This gives a check above and below normal body temperature. It is not necessary to use both temperatures for routine testing in streptomycin studies. In the present studies it is necessary only to determine when the caloric response is changed or absent. This can be done by using water at 30° C. only. It is allowed to run into the external auditory canal in constant contact with the drum for exactly 40 seconds.

The nystagmus is timed from the beginning of the stimulus, thus eliminating trying to decide when it starts. This leaves only one serious variable, the end point. In the absence of a thoroughly trained observer, two observers working together can reach a fairly accurate end point.

The patient is in the supine position, on a back rest, raising the torso to a 30° angle, thus placing the horizontal canal in the optimum position.

The gaze is fixed on a spot on the wall, maintaining the eyes in a straightforward, at rest, position. During the nystagmus the patient is frequently encouraged to maintain this position as steadily as possible. The normal period is usually between 1 minute 50 seconds and 2 minutes 10 seconds. This includes the 40-second stimulation period. A shortening of this period to less than 1 minute 40 seconds is usually considered significant unless of course the pretreatment test was shortened or absent.

Since this test is designed to note minimal changes because it is a minimal stimulus, it follows that no reaction to it could mean a possible residual sensitivity which needed a stronger stimulation to produce nystagmus. Therefore, any patient in this category could not be said to be totally inactive to caloric stimulation. To safeguard against this, all patients showing a negative caloric reaction to the FCH test were retested with 20 cc of ice water. If no reaction was elicited with such gross stimulation it was assumed to be a "dead" labyrinth. No labyrinth was otherwise reported as "dead."

The hearing tests were carried out with a standard Maico D5 discrete frequency audiometer. This instrument was calibrated to normal hearing before use. The tests were carried out in a quiet room of the hospital building. Each patient was screened by a sweep test. The intensity was set at 15 decibels, and response sought at each frequency from 250 to 8000. If no response was obtained at this intensity with any one frequency, a complete audiogram was done. Since it has previously been determined that the deafness resulting from streptomycin is perceptive, only air conduction readings were made. No reading of less than 30 decibels was considered to indicate a hearing loss. (Actually in the majority of cases the hearing loss was extreme and clinically obvious without need of audiometric confirmation. In fact, in several cases no pure tone response could be elicited.)

As far as possible all patients were tested before treatment was started and repeated at intervals varying from two to four weeks during treatment and following cessation of treatment.

Fourteen out of the 61 patients in this study developed deafness, an incidence of 22.9 percent. The distribution of deafness among the various dosage groups is as follows: Eight of 23 patients (34 percent) treated with 3 gms per day for at least 44 days became deaf. Among the group on 3 gms per day deafness first occurred after completion of treatment. Deafness to the spoken voice was noted in seven patients, in six of whom confirmation was obtained by audiometric study. The seventh patient who was deaf

to loud voice died before audiometric examination could be done. Deafness in the eighth patient was apparent only audiometrically.

Among the group of 22 patients receiving 2 gms per day for at least 40 days, three (13.6 percent) became deaf. They were treated for 52, 70, and 100 days, respectively. All were deaf to loud voices. Audiometric study confirmed this.

Of the 10 patients on 2 gms of dihydrostreptomycin hydrochloride plus 12.6 gms of para-aminosalicylic acid, two (20 percent) patients, treated for 80 and 84 days, respectively, became deaf to the spoken voice. In both the deafness was confirmed audiometrically. Thus a total of five or 6.1 percent developed deafness on 2 gms per day.

Of the six patients on 1 gm per day, one (16.6 percent) became deaf to loud voice, confirmed audiometrically.

One peculiarity noticed in this study, not found previously, is the appearance of the deafness following the cessation of therapy, sometimes by as long as three months. This points to the definite need for post-treatment study. Of the 14 patients showing defective hearing, 12 developed this defect one to five months after therapy had been discontinued. This is very difficult to explain.

Of the 61 patients studied, the effect of amorphous dihydrostreptomycin hydrochloride on vestibular function was as follows:

Eleven of the 17 patients receiving 3 gms per day lost vestibular function between 40 and 79 days of treatment. One patient had normal vestibular function at the 91st day of treatment, but lost it in the post-treatment period between the 91st and the 155th day. The remaining five patients were treated for 46 to 75 days, with no loss of vestibular function. This group had caloric tests done as long as 90 days after the treatment period.

Sixteen of the 19 patients treated with 2 gms per day of dihydrostreptomycin alone, showed no loss of vestibular function after treatment periods varying from 36 to 91 days. Three of this group of 19 developed loss of vestibular function between the 40th and the 60th day of therapy. Ten patients treated with 2 gms per day of dihydrostreptomycin plus 9 to 12.6 gms per day of para-aminosalicylic acid given in doses of 2.1 gms at four-hour intervals for periods ranging from 29 to 112 days showed no diminution of vestibular function.

Five patients received 0.5 gm of dihydrostreptomycin twice a day. One of these patients had a loss of vestibular function prior

to therapy due to previous treatment with regular streptomycin. Two patients treated for 56 and 85 days, respectively, have maintained normal vestibular activity. Two patients lost their vestibular function at the 40th and 72nd day, respectively.

To summarize the effect of dihydrostreptomycin hydrochloride on vestibular function in the group of 17 receiving 3 gms per day, 12 (70 percent) lost their function between the 40th and 155th day. Three (16 percent) of the 19 on 2 gms per day lost their function between the 40th and the 60th day. None of the 10 patients receiving 2 gms of dihydrostreptomycin hydrochloride and 12.6 gms of para-aminosalicylic acid for 29 to 112 days lost vestibular function. Two (50 percent) of the four patients on 1 gm per day lost their vestibular function between the 56th and 85th day.

Since the original study on these 61 cases, 150 more have been studied using various types and lots of dihydrostreptomycin.

This was done because it was felt the original hearing loss may have been due to impurities or to the type of drug employed. These patients received dihydrostreptomycin hydrochloride and sulfate, both crystalline and amorphous, with similar results.

No vestibular studies were carried out on this group. Because of previous studies it was felt that the effect on the vestibular apparatus was well known. The important difference to be settled was the effect on hearing. These patients were tested in exactly the same manner and by the same operator as the original group of 61. The intensity was set at 15 decibels, and a sweep through 500 to 8000 was made. If a response was not elicited at 15 decibels, greater intensity was used until a threshold was established. No patient was considered to have suffered a hearing loss in the speech range unless the average loss at 500, 1000 and 2000 had increased by at least 15 decibels over the average of the pre-treatment audiogram. All losses given are in terms of decibels greater than the pre-treatment tests. None of these patients had any acute or chronic ear disease, nor any history of previous severe ear disease which might have contributed to a progressive hearing loss. No patient had fewer than three audiograms. Most had at least four, and some had as many as 12. No less than three months elapsed between the first and last audiogram. In the majority of cases five months elapsed, and in many cases as much as nine to 12 months. These patients were given 2 or 3 gms of the drug combined with 12 to 15 gms of para-aminosalicylic acid per day for a minimum of three months. Most received the drug for five or six months, and some as many as 12 to 14 months.

Simultaneous studies on sensitivity of the tubercle bacilli to the drug were carried out. The para-aminosalicylic acid was given with the dihydrostreptomycin as part of another study on the development of resistance to dihydrostreptomycin by the tubercle bacillus.

Clinically, these patients showed no evidence of vestibular dysfunction; that is to say, no dizziness, nausea, vomiting, past pointing, or locomotor disturbance during or after treatment. Since no caloric studies were done, the true status of the vestibular apparatus is not known at present. In the near future it is planned to make vestibular studies on all patients with a hearing loss. It will be very interesting to determine the amount of vestibular dysfunction accompanying so severe a hearing loss.

An analysis of these cases showed the following:

Audiograms were made of right and left ears. The hearing loss was studied as average loss in the speech range (500, 1000 and 2000 cps) and high frequency (4000 and 8000 cps) loss.

Out of a total of 150 cases, 47 or 31 percent showed hearing losses greater than 30 decibels throughout the 500 to 8000 cps range. These cases were grouped into four parts divided as follows: mild, 30-50; moderate, 50-70; severe, 70-80; and greater than 80 decibels loss.

Losses in the speech range showed there were 19.1 percent in the mild loss (30-50 db) group; 8.5 percent in the moderate loss (50-70 db) group; 10.6 percent in the severe loss (70-80 db) group; and 25.5 percent in the greater than 80-decibel loss group. The high frequency losses were as follows: In the mild loss group, 34 percent; 12.7 percent in the moderate loss group; 17 percent in the severe loss group; and 36.1 percent in the greater than 80-decibel loss group.

The effect on each ear was the same. Both ears progressed toward loss with equal rapidity.

Losses in hearing rarely became evident in less than three months. Many cases progressed even after therapy had been stopped. Tinnitus was complained of in only one case. In most of these cases once the hearing loss had begun, progression to severe deafness was quite rapid even after the therapy had been discontinued. This reaffirmed the observation made in the original study. It would appear, then, that significant deafness as a complication of dihydrostreptomycin therapy is of considerable importance.

This is contrary to all previous reports on streptomycin. All show very few cases of deafness due primarily to streptomycin, and then only when very large doses were used.[4, 5]

There is no doubt about the type of deafness. All tests and observations show it to be neurogenic. Bone conduction tests show losses which preclude any conductive element. These patients show all the speech defects which usually accompany a nerve type hearing loss. They have little or no volume control of voice. They drop and slur the consonants.

Rough discrimination tests show poor discrimination for speech when the hearing loss is not too severe to respond to speech at all. At present all cases have shown no tendency toward recovery. All evidence so far points to a permanent severe loss of hearing, a loss of a type and severity which is not much improved by a hearing aid.

The trend in treatment of tuberculosis is toward long periods of therapy. This is becoming possible now that combinations with other drugs are apparently reducing the occurrence of resistance to streptomycin by the organism.

In view of these trends and the results of this study on hearing, it is felt that streptomycin is probably the better drug since it is better to lose the vestibular control of balance than to lose the hearing. The first can be fairly well compensated, but the latter becomes a permanent and serious uncompensated disability.

The location of the lesion has been a most fascinating mystery since the symptoms were first reported. Histological studies were inconclusive for the most part until recently. The early studies were unable to disclose any definite lesion in the end organ, but did locate some equivocal lesion in the central nuclei.[6, 7, 8, 9]

It has now been definitely established that the lesion in both the vestibular and cochlear systems is definitely in the end organ. Histological studies show a marked degeneration of the hair cells in both the semicircular canals and the organ of corti. Severe poisoning results in complete obliteration of the terminal cells of each. This has been shown by Hawkins,[10] Caussé,[11] and Ruedi.[12] It is now thought that any central lesions are secondary to the peripheral lesions. Now that a definite histological picture of the lesion has been obtained, it is easy to understand why the process is irreversible once well established.

SUMMARY

This is a study to determine the effect of dihydrostreptomycin hydrochloride and sulfate on the auditory mechanism. Two hundred eleven patients being treated for chronic and acute tuberculosis were studied over a period of two and one-half years. The original

group of 61 cases was studied by means of caloric and audiometer tests; 150 more were studied audiometrically only. An average of three audiograms were made for each patient. Some had as high as 12 tests. Approximately 650 audiograms were made over the two and one-half year period. A total of 31 percent of patients showed hearing losses of 30 decibels or more.

CONCLUSIONS

1. Dihydrostreptomycin, whether hydrochloride or sulfate, is toxic to the auditory division of the VIII nerve in doses of 2 or 3 gms per day given for three months or more.

2. Streptomycin is probably the drug of choice where long term treatment is indicated. It is better to lose vestibular function than cochlear function.

3. The hearing loss is progressive in many cases even after the drug has been discontinued.

4. The process is irreversible in all cases in which a significant hearing loss exists.

5. Audiometric studies should follow treatment with dihydrostreptomycin, in all cases.

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XXXI

SOME ASPECTS OF ALLERGIC MAXILLARY SINUSITIS WITH SPECIAL CONSIDERATION OF LATENT ALLERGY

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Our increasing knowledge of nasal physiology and pathology has caused a new outlook on rhinology. But not the least change in this trend is being caused by allergy. Allergy—in the broadest sense—is getting more and more important to all rhinologists.

The nasal and paranasal mucosa has proved to be the most frequently affected shock-organ in allergy. To it has been attributed the role of important defense-organ for the body, but in our dusty world the attacks against this thin lining membrane are so numerous and persistent that the natural defense of the mucosa—the cilia—usually have more than enough to do. In cases of latent or manifest constitutional deficiency of the mucosa it is at the same time attacked from within, and against this guerilla warfare of the allergen-antibody reaction it very often has to succumb.

The incidence of allergic maxillary sinusitis, diagnosed or non-diagnosed, is certainly very high. As the diagnostic difficulties often are very great, it is good to keep the allergic pathogenesis clearly in mind.

In an acute allergic condition the histamine released from the cells by the local trauma caused by the reaction between allergen and antibody brings about an increased vascular permeability, with amounts of tissue fluid of high protein content deposited in interstitial tissue spaces. With the increased vascular permeability and edema of the tissue an increased exudation through the cell membranes and the intercellular spaces will be the other major allergic manifestation.

In the nose proper, with normally easy ventilation forwards and backwards, these manifestations will soon disappear when the allergen by dissolution and ciliary action has otherwise been eliminated.

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The mucous membrane of the nose and paranasal sinuses is a unit, but the allergic pathology of the maxillary sinuses will naturally, because of anatomical and physiological peculiarities, be rather different. During an allergic attack the exudation into the sinuses may be profuse. The edematous swelling will cause a slower, less effective action of the cilia, and most important, the ostia will because of this swelling be partly or completely blocked. Pollen or dust deposited in the maxillary sinus with a blocked ostium may prolong the allergenic action and keep the allergic swelling of the mucosa persistent for quite some time after the external influx of these allergens has ceased.

Edema of the mucous lining and stagnation of tissue fluid render the mucosa much more susceptible to recurrent infection. This has been proved by frequent occurrence of infection in experimental elephantiasis. A hampered function of the cilia, a periodical blocking of the ostia with the edema of the tissue as a good medium for bacterial growth are additional factors facilitating secondary infection, and a superimposed acute infection on such an allergic sinusitis is not far off.

A secondary infection will hamper the physiologic action of the cilia still more, and to make the vicious circle complete it is only necessary to mention that inflammatory conditions of the mucous membrane facilitate absorption of allergens.

If the allergic stimulus is prolonged or frequently repeated, an excessive amount of tissue fluid may remain in the sinal mucosa, become stagnant, and cause irreversible pathologic changes. A chronic lymphatic blockage will be the result. The stagnant tissue fluid will gradually organize, and the fibroblasts will proliferate, resulting in a more or less permanent fibrous overgrowth and thickening of the mucosa. A polyp may develop. If such fibrosis involves the region of the ostium, the ventilation and drainage will be constantly impaired, and a chronic superimposed infectious sinusitis is not far off.

The marked susceptibility of the mucous lining containing stagnant tissue fluid to recurrent infections forms the basis for the frequent infections or "catching cold" experienced by patients suffering from subacute or chronic allergic sinusitis.

Keeping this development in mind, the importance of diagnosing allergy in the first stages is obvious. The first stage of allergy is usually in the first or second decade. Especially during the first decade of life the diagnostic difficulties are very great compared with those with grown-up patients, who may cooperate more intelligently and willingly.

The most important and *condito sine qua non* is for the rhinologist to have time enough for the patient. Patience is necessary for both diagnosis and treatment, and a certain gift and interest for detective work is desirable.

When taking the history, allergy must constantly be borne in mind. Family history is of some importance. It is certain that an inherited factor predisposes to the production of antibodies, but this is probably not essential. Massive contact with allergens can bring about sensitization in an individual giving no family history. Inflammatory conditions of the mucous membranes may facilitate absorption of allergens and may cause a change of reactivity in members of at least apparently nonallergic families.

For the history taking it is advisable to follow a printed scheme in order not to forget any of the many questions. This may be extended individually as circumstances require. Such a printed scheme saves a lot of time and guarantees completeness. The slightest suspicion of allergy at this stage should indicate a complete allergic examination.

The local examination of the nose may give something or nothing. Between the attacks in acute seasonal cases the nasal mucosa may be perfectly normal in appearance, or may show corrugation of the surface.

X-ray examination may tell whether the antral mucosa is thickened or not, and may diagnose intrasinal polyps or fluid levels. But to determine whether a thickened mucosa is the picture of fibrous or hyperplastic mucosa sometimes due to past disease or long-standing allergy or a "pure" inflammatory sinusitis may be more than difficult. When x-ray examination shows thickened lining mucosa and the irrigation gives a negative result, it may often be well to go on with allergic investigations instead of blaming the x-ray for being unreliable.

In this connection it may be worth while to mention the high incidence of undiagnosed maxillary sinusitis passing through hospitals, even otolaryngological departments, for other illnesses, as shown in a recent investigation by Buch.[1] This author re-examined 4,682 patients being discharged from different departments of a central hospital after treatment for some other disease, and found maxillary sinusitis in 8 per cent of these patients. One in four of these patients had no symptoms, 32 per cent had symptoms which might as well have been due to their main disorder, while the remaining 43 per cent showed mostly nasal symptoms, in the vast majority nasal discharge and stenosis, but symptoms they ordinarily

would not have consulted a doctor for. These overlooked symptoms, discharge and stuffy nose, may most likely have been of a mild degree; and it is fair to presume that quite a high percentage has been due to subacute or chronic allergy, as an acute inflammatory condition is not so easily overlooked.

An ordinary allergic examination next brings us to the skin test. This test cannot be relied on solely as a means of diagnosis. When the allergen is an inhalant such as pollen, house dust, a fungus, or feathers, the cutaneous test is relatively accurate and reliable, but in cases of food allergy the skin test in most cases gives little information. Shambaugh[8] estimates 30 per cent positive skin tests in food allergy, but our results with intracutaneous testing show a considerably smaller number.

Conditions such as migraine, angioneurotic edema, urticaria, neurodermatitis, colitis, and other gastrointestinal disturbances scarcely ever show positive skin reactions to food allergens. When any of these conditions are present together with respiratory allergy, a positive skin reaction is invariably related to allergens causing the respiratory allergy. We use the scratch test for pollen, and intracutaneous testing for the rest, as the intracutaneous testing has proved more reliable with the extracts so far available to us.

When so many obviously allergic patients show a negative skin test, there is another factor to consider. Allergy in the broadest sense includes the so-called physical allergy. A certain percentage of allergic maxillary sinusitis is most likely caused by physical allergy. This condition of nonspecific hypersensitiveness of the paranasal mucosa may be due to multiple factors including draft, sudden changes in temperature and humidity, strong vapors, smoke, sunlight or ultraviolet rays, and mechanical irritants. These factors are with our present knowledge not regarded as true allergens, as they are not connected to any protein, and about their reaction with a possible antibody we know nothing.

Skin tests of course give no information in these not infrequent cases. It is our belief that many cases of latent allergic maxillary sinusitis, or allergic sinusitis where the causative allergen could not be found, are often due to this physical allergy. When the nasal and paranasal lining mucosa is anatomically and physiologically to be regarded as a unit, there is no reason to believe that the effect of this physical allergy should be limited to only a part of this mucosa, e.g., that of the nose proper.

At an early stage of the allergic investigation it is advisable to take a smear test of nasal secretion to examine eosinophilia. Eosino-

philia of the shock organ and of the secretion from the shock organ is regarded as more or less constant in nasal and paranasal allergy, whereas eosinophilia of the blood above the normal 2 to 4 per cent is infrequently found in upper respiratory allergy if there is no asthmatic complication. The secretion is taken from the middle meatus as close to the ostium as possible, preferably after shrinkage of the nasal mucosa. Repeated taking of smear is necessary to get a reliable impression.

In a recent paper I have described a cyto-histologic method to determine the degree of eosinophilia in per cent in antral secretion. The "solid" result of antral irrigation is homogenized, centrifugated, and the sediment treated histologically with sections stained after May-Grünwald-Giemsa (Combined Pappenheim) or with Chromotrope 2R. A 5 micron section shows the cells distributed evenly over the field, in one layer only, every cell distinctly stained as in a tissue preparation. The leukocytes with the intensely red-granulated eosinophiles are as easy to count as in an ordinary differential blood count.

As a slight increase of eosinophile cells is often found as a sign of normal healing, only a percentage above seven is of diagnostic significance in allergy. The great advantage of this cyto-histologic method over the smear technique is the possibility of this method to give the eosinophilia in per cent, and is therefore a much more reliable method to differentiate between an antral allergy and an inflammatory maxillary sinusitis in a healing stage.

This cyto-histologic method has recently been used on 78 unselected outpatients at the clinic treated with irrigations and so forth for acute or subacute inflammatory maxillary sinusitis. All showed pus in the result of antral irrigation.

By routine examination none were classified as allergic patients. The history was uncharacteristic and they had had symptoms from the upper respiratory tract for only a few weeks or months.

Of these seventy-eight patients fourteen proved to have eosinophilia in the antral secretion of between 7 and 80 per cent eosinophile cells, as an average 36 per cent.

Three months later eight of these patients with definite eosinophilia of the antral secretion were re-examined to get some further information about their allergy. These eight patients had all had from one to seven irrigations, as an average less than three.

A careful history showed that all but one had had some very slight periodical symptoms from time to time, mostly a stuffy nose

with occasional sneezing and secretion, always regarded as a "cold." One had had only periodical headache and sneezing after some meals. All but one showed positive skin test.

Fungus was positive in six patients, house dust in three, pollen in three. The nasal smear showed some few eosinophile cells in three cases, whereas blood-eosinophilia was present in one case only (9 per cent eosinophiles). None of these patients had had any nasal or other symptoms since their sinuses were irrigated some months ago. The patient suffering from rather frequent headaches before the irrigations, had no headache any more.

Even in an allergy-minded clinic such as this it is difficult during busy hours not to overlook a certain smaller percentage of allergy in patients with maxillary sinusitis. Only by taking a very careful history and using all diagnostic aids at our disposal is it possible in more uncharacteristic cases to clarify the pathogenesis of some cases of allergic sinusitis with a slight superimposed infection.

SUMMARY

Some aspects of allergic sinusitis are discussed.

As a diagnostic aid to determine eosinophilia in antral secretion in per cent a new cyto-histologic method has been used on seventy-eight patients treated as out-patients for acute or sub-acute inflammatory maxillary sinusitis with pus in the antral washings. None of these patients showed at the first routine examination any manifest signs of allergy, and the history was uncharacteristic. The cyto-histologic method used, showed that 18 per cent had marked eosinophilia in antral washings.

A further careful re-examination clarified the picture of acute or subacute allergic maxillary sinusitis with acute superimposed infection. A few antral irrigations were sufficient to break the vicious circle and restore normal ventilation and drainage.

JAC. AALLSGT. 3.

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XXXII

HISTOLOGICAL INVESTIGATIONS IN CHRONIC STREPTOMYCIN POISONING IN GUINEA PIGS

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The question whether the toxic effect of streptomycin on the acoustic vestibular system is localized in the sensory organs of the ear, or in the central nervous system is still under discussion.

Histological investigations published thus far, include descriptions of ganglionic cells and central nuclei in several cases only, which is not adequate to give a full understanding of the toxic effect.

It is the aim of the present paper to present histological pictures of the sensory epithelium, ganglionic cells, the central acoustic, and vestibular nuclei from streptomycin-poisoned guinea pigs. These comprise three series of animals treated with different dosages of streptomycin and one control group.

The action on the vestibular function is recorded by means of the rotatory positional reflex and post-rotatory nystagmus of the head.

The Preyer reflex was used as the indicator of the acoustic function.

EXPERIMENTS

(1) Four guinea pigs were treated with 100 mgs per kilo of Merck's streptomycin, daily, for four weeks. At the end of the treatment, the vestibular reaction was present in all animals, but diminished in two. The Preyer reflex was intact in all. All animals gained in weight during the experiments. The central nervous system was investigated in all, the labyrinths in three.

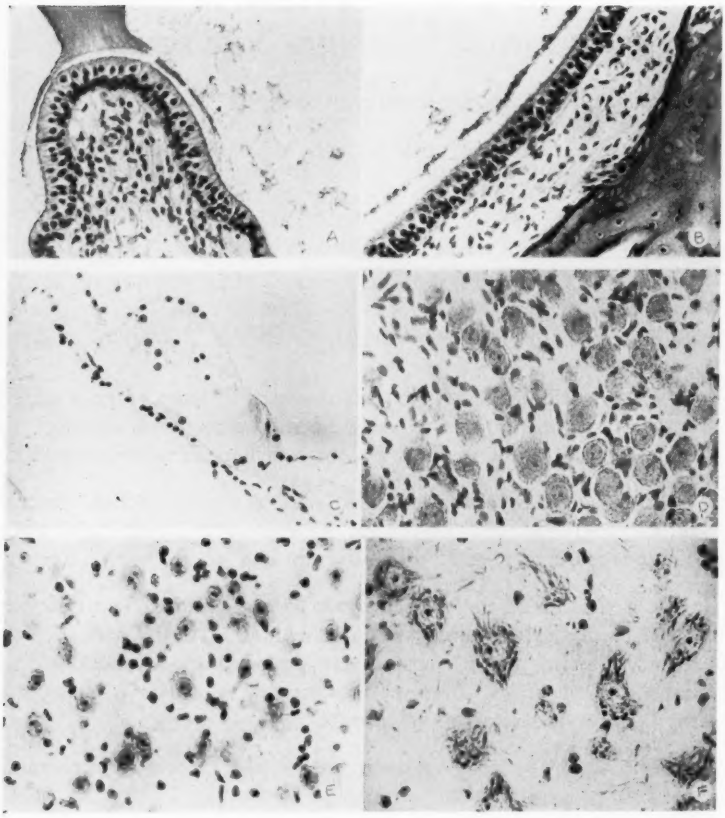

Fig. 1.—Normal animal. *A.* Crista ampullae lateralis. Sectioned almost parallel to the longitudinal axis of sensory cells. Haematoxylin-eosin (x 365). *B.* Macula utriculi. Haematoxylin-eosin (x 365). *C.* The organ of *Corti.* Gallocyanin (x 365). *D.* Vestibular ganglion. Gallocyanin (x 460). *E.* The acoustic tubercle. Gallocyanin (x 460). *F.* The lateral vestibular nucleus of *Deiter.* Gallocyanin (x 460).

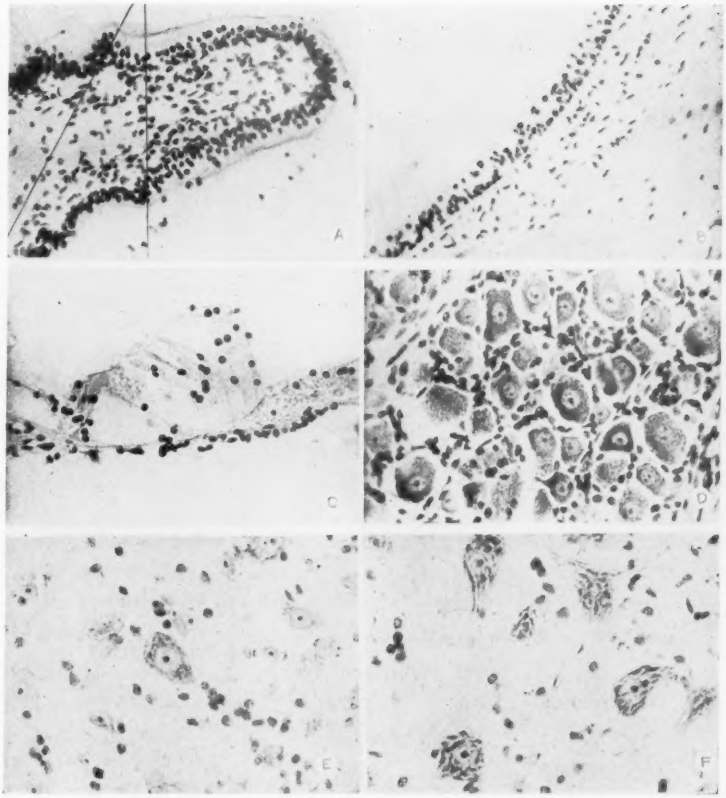

Fig. 2.—Animal treated with streptomycin 100 mg per kilo for 4 weeks, vestibular function and hearing intact. *A.* Crista ampullae lateralis sectioned almost parallel to the longitudinal axis of the sensory cells. Haematoxylin-eosin. Sensory cells intact (x 365). *B.* Macula utriculi. Gallocyanin. Sensory cells intact (x 365). *C.* The organ of *Corti.* Sensory cells intact. Gallocyanin (x 365). *D.* The vestibular ganglion. Gallocyanin (x 365). *E.* The acoustic tubercle. Gallocyanin (x 450). Slight swelling of nuclei and cytoplasm of nerve cells. *F.* The lateral vestibular nucleus of *Deiter.* Gallocyanin. Nerve cells intact (x 460).

(2) Three guinea pigs were treated with 200 mgs streptomycin per kilo, daily, for four to six weeks. The vestibular function was abolished in all, but the Preyer reflex was intact. There was moderate loss of weight. The central nervous system was investigated in all, the labyrinth in one.

(3) Nine guinea pigs were treated with 200 mgs per kilo twice daily, or 400 mgs per kilo, daily, until both vestibular reaction and hearing were abolished on an average of three to four weeks. All these animals lost a considerable amount of weight. The central nervous system was examined in all, the labyrinths in seven.

HISTOLOGICAL TECHNIQUE:

All animals were fixed intra-vitally under urethane anaesthesia by injection into the aorta of 500 mg gum acacia saline solution followed by 500 ml of Wittmaack's fluid. The organs were then removed and kept in 4 per cent formalin saline for further preparation.

The central nervous system, heart, lungs, liver, kidneys, spleen and suprarenal glands were investigated in control animals and streptomycin-treated animals. Paraffin blocks were made, and the preparations from the brain were stained with haematoxylin-eosin, Einarson's[1] gallocyanin chrome-alum mordant and Weil's myelin stain, while the other organs were only stained with haematoxylin-eosin.

The labyrinths were investigated by serial section. When the brains were removed the labyrinths were fixed for two to three weeks, then decalcified according to Kristensen[2] with 8/N formic acid and 1/N sodium formate, equal parts, for two to three days. After rinsing, the preparations were taken through alcohol in increasing concentrations and then through xylol to paraffin or celloiodine. The paraffin blocks were cut in serial sections of 10μ. Of these sections some were stained with haematoxylin-eosin, and others with Einarson's gallocyanin chrome alum mordant.

The histological investigations showed complete uniformity between the animals in each series. The typical alterations in each series are therefore demonstrated adequately by sections from one animal of the series.

The sections were taken from: a) the crista ampullae lateralis, b) the macula utriculi, c) the organ of Corti, d) the vestibular ganglion, e) the acoustic tubercle, f) the vestibular nucleus of Deiter.

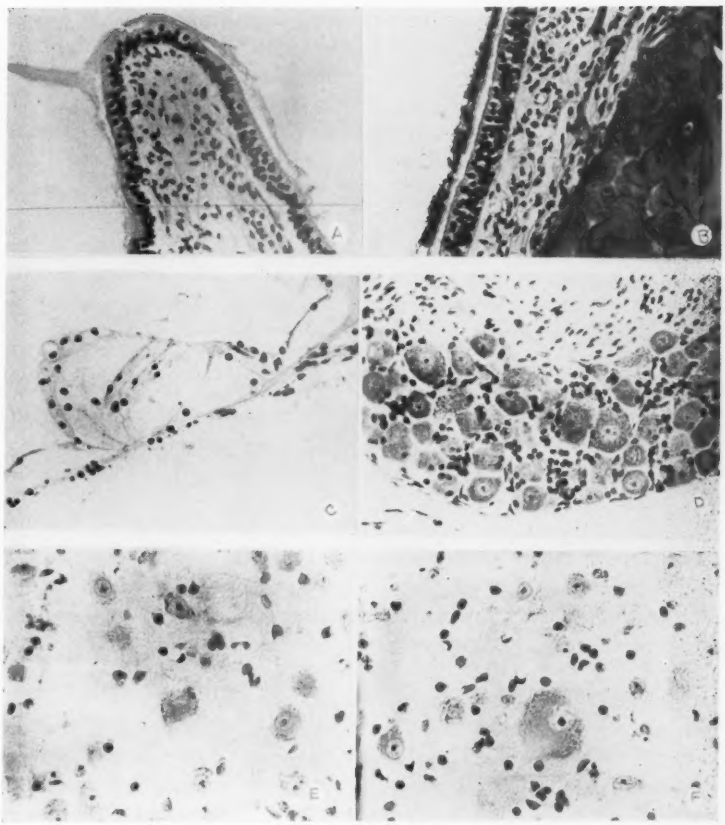

Fig. 3.—Animal treated with 200 mg per kilo daily for 4 weeks vestibular function abolished, hearing intact. *A.* Crista ampullae lateralis sectioned on the slant. Nuclei slightly overlapping. Haematoxylin-eosin. Sensory cells considered intact (x 365). *B.* Macula utriculi. Haematoxylin-eosin. Sensory cells intact (x 365). *C.* The organ of *Corti.* Sensory cells intact. Gallocyanin (x 365). *D.* The vestibular ganglion. Gallocyanin. Nerve cells intact (x 365). *E.* The acoustic tubercle. Gallocyanin. Slight swelling and chromophobi of the nerve cells (x 460). *F.* The lateral vestibular nucleus of *Deiter.* Gallocyanin. Marked swelling, chromophobi and eccentric nuclei in some of the nerve cells (x 460).

DISCUSSION

The histological investigations show degeneration of the nerve cells in the central nuclei, in accordance with the clinical signs of intoxication in the animals. In guinea pigs with destruction of both vestibular function and hearing, alterations in the acoustic tubercle and the vestibular nucleus, was found as described, and also moderate degeneration in the Purkinje cells in the cerebellum. Some of the animals showed slight degeneration of other nerve cells in the medulla oblongata and of the pyramidal cells of the cortex.

Myelin stain of the eighth cranial nerve did not demonstrate degeneration in any one case. Heart, liver, lungs, kidneys and suprarenal glands were normal in all animals.

Our investigations show that streptomycin has a neurotoxic effect primarily involving the central vestibular and cochlear nuclei, but in stronger concentration, or action of longer duration, other nerve cells of the central nervous system are also involved, most frequently the Purkinje cells.

In a previous paper[3] we showed that the microphone effect is normal even in guinea pigs that have lost both vestibular function and hearing after streptomycin treatment. Our histological investigations are in full agreement with these findings.

Summary: Histological investigations in guinea pigs treated with streptomycin from 100 mgs per kilo daily to 400 mgs per kilo daily are demonstrated. In all cases were found degeneration of the nerve cells, in the central vestibular and cochlear nuclei, corresponding with the clinical effect on the animals. Degeneration of cells in the vestibular ganglion, and involvement of the Purkinje cells was found only in the animals most intoxicated. The sensory cells in the labyrinth showed no signs of degeneration in the severest streptomycin intoxication.

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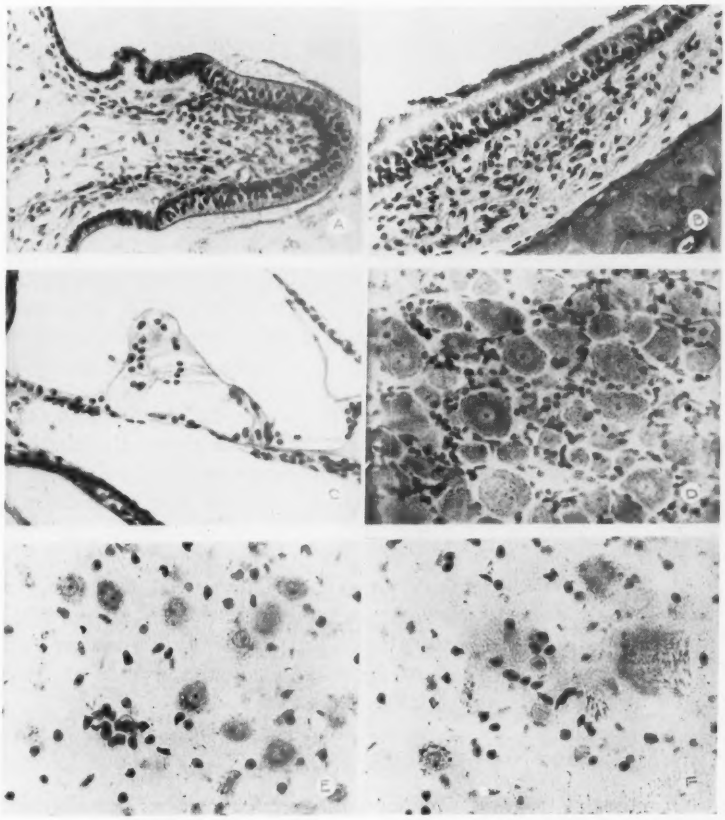

Fig. 4.—Animal treated with 400 mg per kilo daily for 2 weeks. Vestibular function and hearing abolished. *A.* Crista ampullae lateralis. Haematoxylin-eosin. Sectioned on the slant. Nuclei slightly overlapping, considered normal (x 365). *B.* Macula utriculi. Haematoxylin-eosin. Sensory cells normal (x 365). *C.* The organ of *Corti.* Haematoxylin-eosin. Sensory cells intact (x 365). *D.* The vestibular ganglion. Gallocyanin. Slight swelling of the nerve cells (x 365). *E.* The acoustic tubercle. Gallocyanin. Nerve cells in various stages of degeneration. Marked satellitosis (x 460). *F.* The lateral vestibular nucleus *Deiter.* Gallocyanin. Nerve cells in various stages of degeneration (x 460).

XXXIII

CAROTID BODY-LIKE TUMORS OF THE TEMPORAL BONE

WITH PARTICULAR REFERENCE TO GLOMUS-JUGULARE TUMORS

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It is the purpose of this paper to present two cases of mesenchymal tumors of the middle ear, one of which shows the classical features of a glomus jugulare tumor; the other reveals the difficulties of the histopathological classification of some of the mesenchymal tumors originating in the middle ear. These difficulties are pointed out to be twofold: (1) that theoretically any tumor arising from the glomus jugulare may show a marked dedifferentiation leading to the picture of a sarcomatous tumor; and (2) that a mesenchymal tumor originating outside the glomus jugulare may differentiate into either a fibrosarcoma or a hemangioendothelioma, and areas of these tumors may present the features of a perithelioma.

SITE OF ORIGIN OF GLOMUS-JUGULARE TUMORS

The site of origin of jugular bulb tumors was first described by Guild[1] in 1941. He wrote concerning temporal bone sections revealing glomus structures (a small but rich network of cavernous blood vessels) usually found in the adventitia of the dome of the jugular bulb, immediately below the bony floor of the middle ear, and near the ramus tympanicus of the glossopharyngeal nerve. Usually there is but a single, flattened, ovoid glomus, about 0.5 mm in the longer diameter and about 0.25 mm thick. Occasionally two or more smaller bodies are present, sometimes one or all are in the canal that transmits the ramus tympanicus through the floor of the middle ear (in one case also along the course of this nerve over the cochlear promontory).

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Each glomus, wherever located, consists of blood vessels of capillary or precapillary caliber, with numerous epithelioid cells between the vessels. Usually, but not always, the vessels are the more prominent feature. Innervation and blood comes from the same trunks that supply the carotid body; namely, the glossopharyngeal nerve and the ascending pharyngeal artery (through its inferior tympanic branch).

Best[2] describes the glomus caroticum (or carotid body) as a clumping of rounded, polyhedral cells, some of which stain with chromic acid (chromaffin-like cells, yet histologically are proven to have an absence of chromaffin substance[8]) but do not contain adrenalin or behave in an endocrine manner. The glomus jugulare is of like structure, but its exact function is questioned. Some authorities feel that since this glomus is located on the right side of the heart it may function along with the Bainbridge reflex (stimulated by increased blood pressure in the right auricle) and accelerate cardiac action.

REVIEW OF THE LITERATURE AND VARIATIONS IN NOMENCLATURE

Valentin[3] in 1840, described a slight swelling of the tympanic nerve which he felt was a localization of ganglial cells around the nerve, and therefore he called the tumor "ganglion tympanicum." Krause[4] in 1878, thought the enlargement of the tympanic nerve was a glandular formation located between the perineurium and the tympanic canal. He therefore termed the tumor "glandula tympanica," calling the somewhat similar carotid body the "glandula carotica." For anatomically descriptive reasons, the term, tympanic body tumor, has been favored by some authors since it indicates the connection between the tumor and the middle ear.

The first microscopic pattern of a paraganglioma of the carotid-body type was described by Rosenwasser[5] in 1945. In his description the author associates a tumor of the middle ear with the non-chromaffin cells found in the adventitia of the jugular bulb (Guild) and suggests the name, "non-chromaffin paraganglioma."

Other names, such as: hemangioendothelioma, angioma, hemangioendothelial sarcoma, angioendothelioma, etc., have been used to describe the microscopic picture. We shall attempt to clarify this confusion of nomenclature in our discussion of the pathology of the cases presented.

MORPHOLOGY

Grossly, there is no typical appearance of a glomus jugulare tumor. Most often, the mass seen protruding from the external auditory meatus is described as purplish, soft, polypoid, and both friable and hemorrhagic on palpation.

The pathological classifications of glomus tumors are as numerous as the authors reporting cases. Lottis and Wallner[8] feel that the glomus jugulare, as well as the glomus caroticum, glomus aorticum and similar structures (paraganglium intravagale, juxtavagale of Muratori and paraganglium ciliare of Gosses) are "homologous parts of a system of organs consisting of masses of nonchromaffin tissue closely associated with the parasympathetic division of the autonomic nervous system and its ganglion (III, IX, X cranial nerves)." Hollinshead[9] and LeCompte[10] object to the term "paraganglion" being attached to these tumors since histological, neurological, histiochemical and embryological differences between them and the chromaffin paraganglionic system of the adrenal medulla are so numerous.

The microscopic picture reveals a highly vascular tissue with the walls of most of the blood vessels composed of a single-cell endothelial lining supported by a fine reticulum membrane. Between these bundle formations of reticulin fibers, and directly next to the endothelial lining of the blood spaces, are seen ribbons and nests of cells which are referred to, by most authors, as "epitheloid" in appearance. These cells, when closely examined, are seen to be polygonal or rounded with a large amount of clear eosinophilic cytoplasm which may contain many fine eosinophilic granules. Characteristically, the nuclei are frequently vesicular. Mitotic figures are not reported in the morphological picture. These epitheloid cells occasionally stain very lightly while the reticular network may be nicely demonstrated with the aid of silver stain.

Since the origin of this tumor is thought to be in the glomus of the adventitial layer of the jugular bulb,[1] the stem cell is therefore mesodermal. It is our contention that since this is a highly undifferentiated mesodermal layer, any cell here undergoing division is capable of becoming either a fibrocyte, a histiocyte, or an endothelial cell. On this basis it would be conceivable to get a tumor arising from the glomus jugulare which would vary in its gross appearance, its morphological structure, its hemorrhagic tendency, its rate of growth and its response to radiation therapy. This morphological variation would also explain the existing confusion in nomenclature that assumes a tumor is named from its principal cell constituent. This, perhaps, is the reason why mesenchymal tumors of the

middle ear are not associated with the jugular glomus as their primary site of origin.

REPORT OF CASES

CASE 1.—J. H.: This case is that of a 73 year old, white female who was referred to Research and Educational Hospitals May 20, 1950, by her family doctor, because of bleeding from the right ear and a right facial paralysis. History revealed that her paralysis was of sudden onset three months earlier and was concomittant with a hearing loss. The patient had had daily spells of bleeding for the succeeding two months. There was extreme pain in the top of her head with each episode of aural bleeding. She had had excessive right mastoid pain of two weeks' duration. There was no history of previous ear disease.

The physical examination revealed a female with obvious, complete, right-sided VII nerve paralysis. There was a post-auricular swelling and extreme tenderness over the mastoid process, radiating towards the squama. The external auditory canal was filled with old blood, and after cleansing, an obturating, hemorrhagic mass was seen. The hearing tests revealed a complete deafness for conversational and whispered voice in the right ear. On the left side the patient heard conversational voice at 20 feet. The Weber test lateralized to the left and the Rinne test was infinitely negative on the right and positive on the left. The bone conduction was shortened and transmitted to the left ear. Vestibular testing revealed: rotation 10 times to the left produced nystagmus of the first and second degrees of 10 seconds' duration; rotation to the right 10 times produced a nystagmus of the first to third degrees for a duration of 32 seconds; past-pointing was always to the left; the Romberg test was positive with a tendency to fall to the left and backwards. Caloric stimulation with mass douching produced no response on the right side. There was a slight protrusion of the right mandible. X-ray findings showed a large, destructive process over the mastoid involving the tegmen, sinus wall and the posterior fossa. The Stenvers position demonstrated an enlargement of the internal auditory canal and involvement of the horizontal semicircular canal of the labyrinth. The Mayer view showed extensive destruction of the postero-superior wall, and this destructive process extended both anteriorly and inferiorly. A biopsy of the granular mass in the right external auditory canal revealed a malignant neoplasm, type undetermined. The preoperative diagnosis was that of neoplasm of the temporal bone with a latent diffuse labyrinthitis.

Surgery was performed on June 1, 1950, under local anesthesia. A postauricular approach was used. After reflecting the overlying soft tissues, very thin, blue bone was exposed. This paper-thin cortex was removed and the whole mastoid area was found filled with a friable, hemorrhagic, necrotic mass. There were no signs of any intact bone or cells present in the mastoid process. The tumor mass had destroyed the tegmen, the sinus plate and the bone of Trautman's triangle, as well as that of the posterior, external auditory canal. A large erosion of the horizontal canal was found. The incomplete, spontaneous, radical, mastoid cavity was completed after the removal of soft, necrotic bone from the lateral attic wall. The entire course of the VII nerve could be visualized, and it was found to be involved in the necrotic extension of the mass. The labyrinthine bone was "unlocked" so that the entire block could be removed in toto with a Kelly forceps. After this was done, the course of the carotid artery could be followed. Because of gross hemorrhage from the still remaining granular mass, surgery was terminated and the wound tightly packed with iodoform gauze. The patient did well postoperatively for four days and then began a gradual downhill course. She became disoriented and lapsed into a coma on her eighth postoperative day. Consultation from the Neurology Department suggested meningitis or temporal lobe abscess or both. No further exploration was deemed wise at this time. The patient expired nine days postoperatively.

Microscopic examination of tumor masses removed surgically from the temporal bone showed tissue fragments composed of whorls and clusters of cells with oblong, dark-staining nuclei. Tumor cells were either spindle-shaped, fusiform, or polygonal. They were closely spaced except for some vascular channels which did not have separate walls. Their lumina were surrounded only by the tumor cells. Silver stain preparations exhibited reticular fibers between the tumor clusters, forming a honeycomb-like network.

Microscopic examination of the sequestrum removed from the labyrinth of the right temporal bone showed bony rarefaction of the periosteal layer throughout the whole nucleus of the labyrinth. The ingrowing tumor masses reached, in different areas, the enchondral bony layer. The deepest tumor infiltration occurred from the ventral surface of the labyrinth and grew into the promontory wall, medial to the eustachian tube. The tumor extended into the endosteal layer of the labyrinth in the areas of both windows, and entered the perilymphatic and endolymphatic spaces of both the vestibule and the semicircular canals. Around the whole nucleus of the labyrinth and in the labyrinthine cavities, the tumor consisted

Fig. 1.—Drawings of the labyrinthic sequestrum surgically removed. Above, ventral surface of the labyrinth with the carotid canal; below, view of the promontory wall with ossicles.

of irregular-shaped cell clusters surrounded by small amounts of stroma. Vascular channels of various calibers were encountered adjacent to the tumor masses. In deeper isolated areas of the petrous bone, tumor clusters were seen filling the larger and smaller vascular canals. The involved labyrinthine bone presented the picture of a premorbid bone. This was characterized by a complete lack of defensive reaction and of new bone formation on the surfaces of the labyrinth adjacent to the tumor. The resorptive indentations of the bone were more abundant in the areas of the richly vascularized tumor. The Haversian and Volkmann's canals were partly filled with a few tumor cell clusters. The osteocytes were entirely absent and the lacunae empty. The internal auditory and facial canals were empty and somewhat enlarged. The periosteum of the inner canal appeared somewhat thickened. Peripherally, and at the fundus of the inner canal one could find nests of tumor masses attached to the periosteum and circumscribing the residual vessels. The bony framework around the cochlea showed normal configuration. The enchodral layer exhibited signs of degeneration in the bony matrix, as did the globuli ossei.

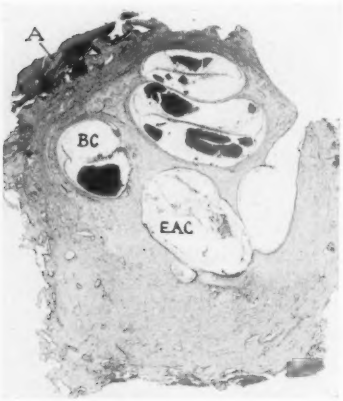

Fig. 2.—View of the labyrinthic sequestrum with progressive destruction of the periosteum and enchondral layer. Accumulation of blood in both scalae; empty inner acoustic and facial canals. *A*, Apex; *BC*, Basal Coil; *EAC*, Empty Acoustic Canal.

Fig. 3.—Vertical section through the labyrinth. Progressive destruction of labyrinthic bone. Dislocation of stapes. Blood in cisterna perilymphatica. Compression of utriculus. Blood and tumor masses in the round and oval window. S, Dislocated stapes; *PC*, Perilymphatic cistern; *RW*, Round window.

Fig. 4.—Tumor infiltration of labyrinthic nucleus along the pre-existent vessels.

Nerve fibers of the modiolus and ganglion of Rosenthal showed typical reactions of degernation with decay of fibers, vacuolization of cell protoplasm, loss of chromatin in the nuclei, and a complete disintegration of ganglion cells with a deposition of brown pigment.

Both scalae were filled with red blood cells; the scala tympani more so than the scala vestibuli. The cochlear duct proper was free of blood and pathological changes. Corti's organ appeared relatively well preserved. The spiral ligament, the vascular stria, and the limbus were all normal. Only Reissner's membrane was curled and flattened near the base.

Analagous pathological changes were found in the bone of the vestibular wall. The pressure of the tumor against both fenestrae caused a dislocation of the stapes into the vestibule, and the tumor masses were seen to be extending from the middle ear into the vestibule and through the gap in the oval window. The perilymphatic cisterna was partly filled with blood and tumor cells.

The utricular and saccular membranes appeared thickened, and near the maculae they were compressed by the accumulation of blood. The ampullae of the horizontal and vertical canals were deformed and compressed. The nerve fibers in the cribriform bone showed signs of degeneration. There was a large, (about 1½ mm long) fistula in the horizontal canal with ingrowth of tumor cells into the peri- and endolymphatic spaces.

In the superior and posterior canals, blood was found in the perilymphatic spaces, causing a compression of the membranous canal. The niche of the round window was filled with blood and the secondary membrane was covered with tumor cells. A large tumor mass destroyed the labyrinthic nucleus, and was seen growing along the vascular canals in the central portion of the bony block.

CASE 2.—I. B., a 56 year old, white female presented herself to the Illinois Eye and Ear Infirmary on February 23, 1950, accompanied by a letter from her physician asking that the patient receive further postoperative care of a right mastoidectomy.

Her history revealed that she had noted a slight loss of hearing bilaterally, when she was a child, but she had done nothing about this. Approximately ten years prior to admission, at the age of 46, she experienced an earache, and apparently a myringotomy was done at that time. Subsequently, a purulent discharge was noted for a few weeks. For seven years following this episode, she had noted bleeding from the right ear, associated with upper respiratory infections or "straining" efforts. Some of these hemorrhages were most profuse and were stopped only by tight, external packing of the ear. About three years prior to admission, she had a hemorrhage that came from her right ear, nose and mouth. It was suggested to her that she might have a tumor, and surgery was advised at that time. This, however, she refused. In February, 1949, she noted a sagging of the right side of her face. In August, 1949, the patient had a large swelling on the right side of the neck and behind the ear. For this swelling she was hospitalized and given penicillin over a two week's course, and then discharged. Another acute swelling developed February 4, 1950, and this time she was operated upon by the referring physician, who stated in his letter that "complete surgery was not done due to the severe hemorrhage encountered during the procedure." A drain had been put in the operative site and the area closed. The patient was given penicillin for two days prior to surgery and five days thereafter. Seventeen days postoperatively, the patient again developed swelling and postauricular discharge. It was in this condition that she presented herself to the Illinois Eye and Ear Infirmary.

Examination on admission showed a white female with a complete, right-sided, facial paralysis. The patient held her neck and head turned slightly to the right. There was a large, fluctuant area in the postauricular tissue, extending downwards into the neck and upwards into the parietal area as far as the temporal line. There

was a profuse discharge of purulent material coming from the postauricular wound, 5 cm behind the auricle. Manipulation of the concha was exquisitely painful. There was a moderate amount of drainage from the right external auditory canal, and a hemorrhagic mass was seen obturating the canal. The left ear was normal. Conversational voice on the right was limited to 6 inches and whispered voice was not heard. On the left, conversational voice was heard at 20 feet and whispered voice at 8 feet. The Weber test was lateralized to the right side. The Rinne was negative on the right and positive on the left. The Schwabach was prolonged on the right. The fistula sign was negative. On turning the patient 10 times to the left, nystagmus of the first to third degree was seen, and conforming past-pointing and falling reactions were elicited. Nausea and vomiting followed this rotation. Rotation 10 times to the right also produced nystagmus of first, second and third degrees accompanied by nausea and vomiting. X-rays showed a normal left mastoid process. X-ray views of the right demonstrated an incomplete, operative defect with clouded cells posterior to this area. The petrous ridge was dense and hazy on the right.

Because of profuse bleeding, biopsy was not attempted prior to surgery, but malignancy was suspected.

The patient was brought to the operating room on the morning following the day of admission and a postauricular incision was made an inch anterior to the previous surgical scar. The skin was reflected and a granulating mass led to the original surgical defect, which was found to be 4 cm behind the external auditory canal. The cortex was removed and the mastoid showed marked cellular destruction. The cavity was filled with a friable, hemorrhagic mass. The sigmoid sinus was found to be anterior to the site of previous surgery and covered with soft, necrotic bone. The horizontal canal was similarly covered with necrotic bone, and removal of this tissue revealed an erosion. The radical mastoidectomy was completed and the VII nerve was seen floating freely in the region of the horizontal canal. In the tympanum much hemorrhagic tissue was encountered, and when an attempt was made to remove this, profuse bleeding ensued. The procedure was terminated and a tight pack was inserted into the defect.

During the postoperative period the patient developed a serous labyrinthitis which subsided in one week. Considerable hemorrhage was encountered each time the dressing was changed (for 32 days). This continued in ever decreasing quantities until March 12, 1950, which was 47 days postoperative. The patient was discharged on May 30 to the care of her private physician.

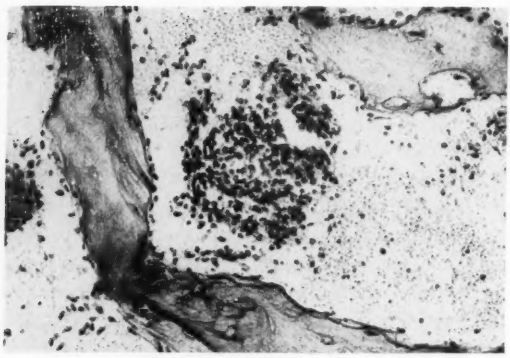

Fig. 5.—Typical glomus cluster consisting of epitheloid cells adjacent to a bony bar.

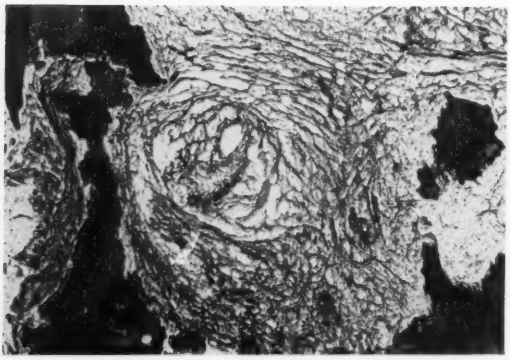

Fig. 6.—Silver stain of fibrillar-reticular framework surrounding the epitheloid cells.

In July, 1950, six weeks after her discharge from our care, the patient reappeared with a draining, bleeding fistula behind the right ear. She was treated with penicillin, and because of excessive granulation tissue, was sent for x-irradiation. She received 1500r over a five week period. The overgrowth of the granulation tissue subsided. Complete healing resulted after irradiation and curettage of the fistula.

Sections of bone taken from the mastoid revealed fibrosis of the marrow spaces with some thickening of the spicules and a loss of the osteocytes from the lacunae. Several large fragments of fibrous tissue, numerous blood vessels and cords of cells were seen. The typical microscopic picture of an endothelial, glomus-tumor was found. This consisted of isolated clusters of round and ovoid cells; these were generally eosinophile, with large, dark-staining nucleoli. These clusters were not always accompanied by vascular tissue. The cells were found to be surrounded by argentophile fibers. This cell pattern was identified by the Department of Pathology as a glomus tumor.

DISCUSSION

A review of the clinical courses of cases reported in the literature reveals the onset of symptoms anywhere from 5 to 78 years of age.[6, 7] The most common symptoms reported are; chronic aural discharge, loss of hearing, (slight at onset progressing to deafness) tinnitus with occasional episodes of dizziness, throbbing sensations in the involved ear, hemorrhage from the ear (especially on manipulation), facial paralysis, polyps obstructing the external meatus, (these bleeding profusely when instrumented) and late evidences of extension manifested by dysphagia, hoarseness and pain. Caloric testing, carried on postauricularly, and rotation tests usually reveal an impaired labyrinthine response on the involved side.

It would appear that the tumor occurs most often in females (9 to 2 in one series,[7] 14 to 2 in another[6] and 13 to 5 in still a third[8]). The duration of symptoms seems to depend fairly much on cell type and direction of extension, and is reported to vary between nine months and twenty years. Our patients, both females, complained first of pain in one case, and of hemorrhage and facial paralysis in the other, and this was one to three months prior to first examination.

Lundgren[6] states that in the sixteen cases he reports (a cumulative report up to and including August, 1949) there was no evidence of metastasis. He does state that unless radical surgery is performed, however, there tends to be local recurrence, and this may

be years after the initial complaint. In two of the eight cases presented by Lottis and Wallner[8] metastases are known to have occurred; one to a cervical lymph node, the other to the liver. Metastases to the liver and lungs were demonstrated in our first case. These areas were seen microscopically to be small, focal seedings of endothelial cells.

Here again, it is our contention that glomus jugulare tumors of a more fibrous or acellular structure will be less liable to extend beyond their local sites of growth, than a glomus tumor of a more cellular type which may be seeded via the vascular tree to distant foci. Our first case appears to fulfill this latter premise.

As was demonstrated in the mastoid x-rays of the two cases presented, there is no specific x-ray evidence differentiating the middle ear pathology caused by a glomus jugulare tumor from that caused by any other malignant lesion of this location. These lesions are progressively expansive in the middle ear, revealing in sequence to the clinician: a blue-bulging drum, then destruction of the drum with a protrusion of a granular mass (purplish, soft polypoid) into the external canal. This rapid expansion may cause an erosion of the external canal, if hemorrhage has not already brought the patient to the attention of a surgeon. Medially, the tumor rapidly outgrows the confines of the middle ear and may extend along the petrous pyramid, circumscribing the labyrinth in the dorsal part of the pyramid, and eventually into the cranial cavity with a subsequent compression of central nervous structures and one or more cranial nerves.

A review of the literature reveals the treatment of choice of these tumors of the middle ear to be wide surgical exposure with radical resection. Lundgren[6] states that these tumors, being of a carotid-body-type, do not respond to radiation. Winship,[7] in two cases, irradiated "malignant glomus jugulare tumors" without benefit. Radium packs to the cavity with repeated coagulations to suspicious, recurrent tissue over long follow-up periods have met with limited success.

Since it is difficult, even with mastoid x-rays, to predict the morphology of the tumor preoperatively, we suggest the following regimen:

a. Radical mastoidectomy or labyrinthectomy, or both. The extent of the surgery naturally depends on the gross extent of the lesion and the reaction of the labyrinth to clinical testing. If the lesion is so advanced that not only the mastoid, but also the lateral sinus and the dura of both the middle and posterior fossae are involved, then

the ligation of the large cervical vessels (external carotid artery and internal jugular vein) may be necessary.

b. Routine postoperative x-irradiation.

c. A close, long-term postoperative follow-up with biopsy of all suspicious tissue.

SUMMARY

1. The site of origin of glomus jugulare tumors is described and illustrated.

2. Various names have been given to this tumor of the middle ear, most of them with an erroneous connotation regarding morphology or site of origin.

3. Two new cases are added to the number already reported in the literature.

4. A digest of the most common symptoms is reported.

5. The characteristic, pathological picture of a glomus jugulare tumor is presented with a possible explanation of the failure of many middle ear tumors to be identified as having their origin in the jugular glomus. The difficulties of diagnosing these tumors is pointed out, and the fallacy of diagnosing all such tumors as hemangioendotheliomas. It is equally erroneous to say that all hemangioendotheliomas of the middle ear should be classified as glomus jugulare tumors. Recognition of the fact that the mesenchymal stem layer of the glomus tumors is highly dedifferentiated is urged.

6. A description of labyrinthine sequestration as well as metastases to the liver and lungs, is presented in the illustrations of the two new cases.

7. The absence of any typical x-ray picture differentiating this tumor from any other expanding tumor of the middle ear is emphasized.

8. A suggested regimen of treatment is offered.

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XXXIV

NON-OSTEOGENIC FIBROMA OF THE JAW

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It is to Jaffe and Lichtenstein's[1] credit to have created, in 1938, a new nosological entity in regard to bone, by separating from the vast group of so-called "fibrous cystic osteodystrophy" a disease which, at first, they had named "polyostotic fibrous dysplasia" and later "fibrous dysplasia of bone." The lesion may be defined, in accordance with its microscopic pattern, as a fibroma where the matrix tissue shows a strong tendency to ossification and even to chondrification.[2]

The fibrous tissue however is not subject to osseous metaplasia, but represents another nosological entity created in 1942 by the same authors, i.e.: non-osteogenic fibroma of bone.[3] The lesion which is chiefly observed in older children and adolescents, has a predilection for the shafts of long bones. Although the ten cases they observed do not include any instances of non-osteogenic fibroma of bone in other than long tubular bones, Jaffe and Lichtenstein assume that "there is reason to suspect that the lesion does occasionally appear also in other bones." The chief aim of our note is to make the record of a case of non-osteogenic fibroma of the jaw.

REPORT OF A CASE

B. M., a female aged 22, was admitted to the hospital on September 5, 1949. The remote family and personal anamnesis did not reveal any details of interest, excepting a late beginning of menstruation (at the age of 17).

Five years ago, the patient had the first inferior right molar extracted, but the evulsion was difficult and incomplete. A year later, she became aware of a hard painless little mass in the lower right jaw fornix, in the neighborhood of the extracted tooth. This

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From the Clinica otorinolaringologica dell'Università di Milano and from the Laboratorio anatomo-patologico del Pio Albergo Trivulzio di Milano.

Fig. 1.—Photograph, showing the tumor.

Fig. 2.—Roentgenogram of the lower jaw before operation.

mass continually increased but without causing pain, until it reached the present size. When the patient about a year ago came to our hospital, a roentgenograph was taken; biopsy examination suggested, was declined.

When the patient was admitted to the hospital, external examination (Fig. 1) revealed the presence of a swelling of the size of a small mandarine (diameter ca 5 cm) in the right jaw, covered by normal skin which was not adherent to the growth. The swelling was smooth, and hard, inelastic, almost woody. Palpation did not cause pain; it was firmly adherent to the jaw-bone and its borders not well defined. Examination of the oral cavity reveals an almost complete tumefaction of the right jaw fornix, it extending in fact, to the back corner of the jaw. The mucous membrane covering the mass appears normal. The first inferior molar was missing without particular alteration of the gum.

Roentgenographic examination of the right side of the jaw (Fig. 2) showed a conspicuous alteration of the bone structure with numerous irregular areas of rarefaction separated by thin loosely interspersed septa which, at their crossing points, form outlined density zones. The lower border of the jaw, thinner and interrupted in one place, was irregularly bulging. The lesion described comprised the area from the canine to the ramus of the jaw. The roots of the missing molar were still in their sockets. Tomographic examination by front layers confirms the disorder of bone structure in the right half of the jaw, where the zones of increased transparency appear as loculi of various shapes and sizes.

On September 17th, the roots of the first molar were extracted; after cutting the jaw and dissecting the soft tissues from the osseous part, the cortex was demolished in the area of the upper external surface. In this way, a few cavities of various sizes, from that of a pea to that of a bean, filled with amorphous white lardoceous tissue, tenaciously clinging to the bone were opened; this tissue was removed for histological examination.

On October 6th, under general endotracheal anesthesia, the right inferior third, fourth, seventh and eighth teeth were extracted and the new growth was removed in small fragments. This new growth consisted of several cavities, filled with the same tissue revealed at biopsy. The cortex of the jaw was totally removed down to the corner. Bleeding stopped through coagulation. The post-operative course was uneventful.

Microscopic examination (Fig. 3 and 4) evidenced a typical fibroma completely lacking in osteogenetic activity. Here and there,

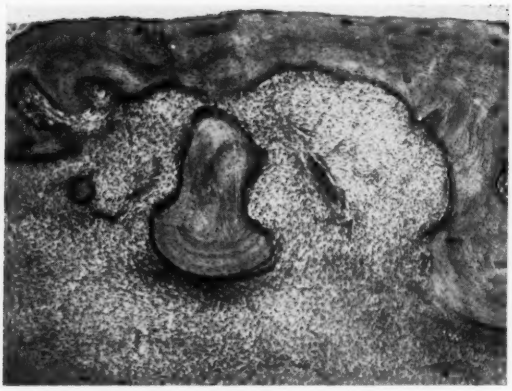

Fig. 3.—Photomicrograph. Above, the osseous capsule of the fibroma, composed of lamellar bone tissue. From the capsule start two perpendicular septa also consisting of lamellar bone which enter the mass and are responsible for the multi-cameral aspect in the roentgenogram (x 28).

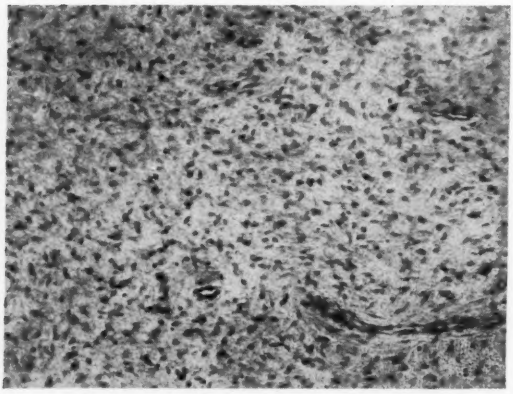

Fig. 4.—Photomicrograph. The specimen is composed of rather compact collagenous fibers, in which fibroblasts are distributed rather regularly (x 120).

are traced little bits of lamellar bone tissue, i.e. the septa which are responsible for the multicamerial aspect in the roentgenogram (Fig. 3).

The histological findings, therefore, show the existence of a non-osteogenic fibroma of the jaw. The course of the disease is in accordance with the description of Jaffe and Lichtenstein: Outbreak of disease at 17 years of age; no characteristic clinical manifestations; slow progress of development; and the roentgenological aspect of the lesion.

Summing up the cases described in the literature as fibroma of bone, the authors state: "The term has most often been applied to lesions (particularly in the jaw bones) of the same character as those which have also been denoted as ossifying fibroma or fibrous osteoma. It has likewise been applied (again particularly in relation to the jaw) to lesions of the nature of solitary foci of fibrous dysplasia."

Publications following that of Jaffe and Lichtenstein do not seem to contain descriptions of specific cases of non-osteogenic fibroma localized in the jaw bones, analogous to the case we have observed.

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XXXV

TUBERCULOUS PERIPHARYNGEAL ABSCESS

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Infection of the pharyngeal spaces by the tubercle bacillus is not rare, but the mode of development and the duration in the case to be presented seem sufficiently unusual to make it worthy reporting.

Tuberculous infection of the fascial spaces of the neck has been known for centuries, but until the discovery of the bacillus by Koch, the exact cause was not recognized. Morell MacKenzie,[13] discussed cases of retropharyngeal abscess in children, some due to cervical spondylitis and others idiopathic in origin, a large number of the latter exhibiting a scrofulous diathesis. Gautier[7] mentions a case of scrofula with involvement of the cervical lymph glands in which a retropharyngeal abscess developed later.

Tuberculosis of the fascial spaces of the neck originates either from caseating lymph glands in the spaces or from tuberculosis of the cervical vertebrae, since the anatomy of these spaces has been covered so thoroughly by Iglauer,[10, 11] Grodinsky,[8, 9] Weintraub,[24] and Beck,[1] it will not be necessary to review it, except to point out the difference in sites of these two types. The former is due to the breaking down of an infected lymph gland (often called Little's or Henle's gland), which is in intimate topographic relationship with the upper portion of the peripharyngeal space and is located in spaces three or four as described by Grodinsky. (Space three is the space between the visceral and alar fasciae and space four lies between the alar fascia and the prevertebral fascia.) The abscesses resulting from tuberculous involvement of the cervical vertebrae collect behind the connective tissue covering of the spine in space five described by Grodinsky, this being the space posterior to the prevertebral fascia. Richards[18] reports the pharyngeal lymph nodes as being located usually to the left or right of the midline at varying levels, so high as to be hidden behind the soft palate or so low as to be retrolaryngeal or retroesophageal.

Reviewed in the Veterans Administration and published with the approval of the Chief Medical Director. The statements and conclusions published by the authors are the result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

Cases of tuberculous abscess of the pharyngeal spaces not of vertebral origin, have been reported by Iglauer[12] and Smith.[23] Bremer and Wykered[2] stated that chronic retropharyngeal abscess is due to invasion of the retropharyngeal lymph glands from the deep cervical glands and Smith[22] believed that tuberculous retropharyngeal abscess in the adult need not be dependent upon cervical vertebral involvement. Morrison[15] stated that there is a chronic form of cold abscess of the pharynx usually due to tuberculous caseation of the retropharyngeal lymph nodes or to tuberculosis of the upper cervical vertebrae and Magnien[14] stated that cold retropharyngeal suppurative collections frequently begin in the prevertebral lymph nodes: tuberculous prevertebral adenitis, but the large majority of cases are cold abscesses of the cervical vertebral column. Rimer[21] believed that very few retropharyngeal abscesses were secondary to tuberculosis of the cervical vertebrae, while Bryant,[3] Davidson,[4] and Gaines and Hatcher[6] believed most of these in the adult were the result of cervical vertebral disease. Deering and Brennemann[5] thought that these abscesses were rare after the period of infancy, because the glands were said to atrophy after the third of fourth year.

The diagnosis of peripharyngeal abscess is made by the finding of a fluctuant mass in the postero-lateral angle of the pharynx without the tonsil being pushed forward. The overlying mucosa may be pale or injected. Rathbone[17] described the technique for making the diagnosis by roentgenograms of the pharynx.

During the past century, the treatment of this condition has varied. Gautier[7] reported a case in which the abscess was incised internally, while Smith[22] advocated external drainage. Magnien[14] employed incision and if recurrences appeared, the use of local injections of medications along with ultra-violet radiation and ozone. Rathbone[17] believed that if the adenititis was treated in the early stages with roentgen rays, an abscess rarely developed. Smith[23] effected a cure by the combination of internal drainage and streptomycin.

There have been many reports[16, 19, 20] in the literature of hemorrhage, sometimes resulting fatally, as a complication of pharyngeal abscesses, but none of these were in cases of tuberculous origin. Probably this is due to the slowness of development which allows time for the walling off of the abscess.

REPORT OF A CASE

H. P., a white male, 32 years of age, was admitted to this hospital on June 22, 1950 for treatment of pulmonary tuberculosis

which had had its onset in 1944 and for which he had sought treatment in various hospitals, but in which he never had remained for any length of time. Examinations revealed far advanced pulmonary tuberculosis with bilateral cavitation and enlarged anterior cervical lymph nodes with bilateral draining sinuses. The sputum and pus from the neck were positive for acid fast bacilli on both smear and culture. The patient was seen on August 30, 1950 because of pain on swallowing and examination revealed bulging of the left posterolateral portion of the pharynx, posterior to the left posterior pillar. The bulging was fluctuant. Roentgenograms showed no disease of the cervical vertebrae.

The patient had been seen by the author at another hospital in August, 1944, at which time a similar pharyngeal swelling in the same location had been found and had been aspirated. The pus was positive for acid fast bacilli. Roentgenographic examination failed to reveal any pathologic process in the cervical vertebrae. The patient left the hospital before any treatment could be given.

On August 31, 1950 the mass was aspirated and 5.5 cc of thick greenish pus was obtained. This was positive for acid fast bacilli on both smear and culture. While awaiting the outcome of streptomycin sensitivity studies, the mass was aspirated again on September 5 and September 11, 2 cc and 1.5 cc of pus being obtained. The organisms were found to be sensitive to 0 to 1 mcgm of streptomycin. The patient was given 1 gm of streptomycin a day for 78 days along with 3 grams of para-aminosalicylic acid four times daily. The pharyngeal swelling subsided but recurred on October 6. Aspiration yielded 1 cc of pus and 0.5 gm of streptomycin in 0.5 cc of solution was instilled. The mass subsided slightly and on October 12, 0.5 cc of pus was aspirated and 0.5 gm of streptomycin was instilled. There was a marked decrease in the size of the mass, but swelling again appeared on November 1, at which time 0.5 cc of pus was removed and 0.5 gm of of streptomycin was injected. The swelling did not reappear during the time the patient remained under observation. He left the hospital without permission on December 11, 1950, with no improvement in his pulmonary condition, but the cervical sinuses and the peripharyngeal abscess apparently were healed.

SUMMARY

A case of tuberculous peripharyngeal abscess of at least six years' duration has been reported. This evidently was secondary to tuberculous adenitis of the anterior cervical lymph nodes and was treated by aspiration, local and systemic administration of streptomycin and para-aminosalicylic acid.

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XXXVI

OTOSCLEROSIS OF THE OSSEOUS HORIZONTAL SEMICIRCULAR CANAL

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AND

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With magnification of seven to ten times employed in the fenestration operation, by means of the binocular operating microscope as first described in 1922 by Gunnar Holmgren,[1] and later applied to the one-stage Lempert fenestration operation in 1940 by one of us,[2] gross pathologic lesions of otosclerosis are frequently observed in the oval window region. The area of pathologic bone almost invariably lies immediately anterior to the oval window, impinging upon the anterior crus of the stapes. Sometimes the mound of new bone is covered by thickened hyperemic mucosa in contrast to the normal extremely thin and almost avascular mucosa of the remainder of the tympanic cavity. At other times the focus is seen as a circumscribed area of white chalky bone sharply demarcated from the yellowish normal bone of the promontory. When the focus is large most or all of the stapes footplate is replaced by a thick plaque of pathologic bone, so that the crura of the stapes appear shortened as they spring from the otosclerotic bone. Occasionally the anterior crus will be greatly enlarged by extension of otosclerotic bone into it. Palpation of the head of the stapes reveals it to be solidly ankylosed (if the crura were not fractured in removing the incus) when the preoperative air-borne gap is 50 or 55 decibels. When the preoperative loss is less than 40 decibels the stapes proves to be very slightly movable when tested with the probe (but not at all freely movable like the normal stapes as observed in the Cawthorne or the Day operation for labyrinthine hydrops).

In the great majority of fenestration operations the otosclerotic focus does not extend to the osseous horizontal semicircular canal. However, in an occasional rare case the surgeon will observe, while making the fenestra, a circumscribed area of abnormal bone in the wall of the semicircular canal. The abnormal bone is recognized

by its distinct softness and friability under the dental plug finishing burr, as contrasted with the ivory-like hardness of the normal capsule. The abnormal bone also differs in color being whiter (or pinkish when very vascular) than the yellowish coarsely granular bone of the normal endochondral layer of the capsule as seen through the operating microscope with a continuous flow of sterile saline or Ringer's solution to keep the field immaculately clean. The line of demarkation between pathologic bone and normal bone is often very sharp and somewhat irregular.

In three such cases a small piece of the pathologic bone was broken off with a curet and removed for biopsy. In each instance histologic study revealed the typical bone structure of otosclerosis.

The first patient in which the clinical diagnosis of otosclerosis was thus confirmed by biopsy during life, was as follows:

Mrs. M., Northwestern University Fenestration Series No. 106, was first examined at the age of 41 by one of us on September 15, 1941, with the complaint of progressive deafness of 15 years duration. The audiometric and tuning fork tests showed a severe conduction deafness with early high tone nerve involvement (Fig. 1). On the basis of the history, the hearing tests, and normal appearing tympanic membranes with a distinct pinkish glow from both promontories (Schwartze's sign), the clinical diagnosis of otosclerotic stapes ankylosis was made. The patient was given a limited (Class "B") prognosis for fenestration, but nevertheless decided to try the operation in the hope that she might be able to get along without her hearing aid in her occupation as school teacher.

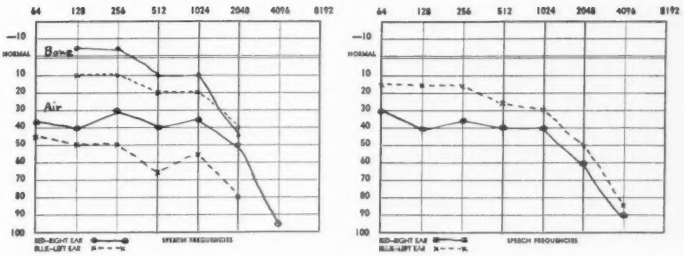
Fenestration of the left (poorer hearing) ear was performed on September 29, 1941, using the Lempert nov-ovalis procedure with continuous irrigation and the operating microscope to obtain a bone-dust-free fenestra. Three months postoperative there was an average gain of 30 db for the speech frequencies (Fig. 1), the hearing being brought from a 65 loss to an average loss of 35 db. With this improvement she returned to teaching and was able to get along without her hearing aid, but since she was still somewhat handicapped fenestration of her second (right) ear was undertaken June 12, 1942.

The mastoid was normally pneumatized. The contour of the osseous horizontal semicircular canal when exposed in the medial wall of the attic, however, was deformed by a bulbous protuberance covered with a thickened hyperemic mucosa. In making the fenestra with the plug dental finishing burr this protuberance proved to be composed of soft chalky bone, sharply demarkated and quite different from the hard yellowish ivory-like bone of the endochondral layer of the normal capsule. The abnormal bone extended through all three layers of the capsule, down to the endosteal membrane, but although it protruded into the attic as an exostosis, it did not encroach upon the perilymph space of the semicircular canal.

A piece of the pathologic bone was easily broken off with a 000 curet and removed for histologic study. The completed fenestra lay almost entirely surrounded by the pathologic bone, only the posterior fifth lying in normal capsular bone. The stapes when tested with the probe was immobile.

Histologic examination of the fragment of bone removed at operation showed the typical structure of otosclerosis (Fig. 2).

Post-operative audiograms at no time showed any gain in this second operated ear, but rather a further loss (Fig. 3).



Preoperative: Sept. 27, 1941 3 months postoperative: Jan. 6, 1942

Fig. 1.

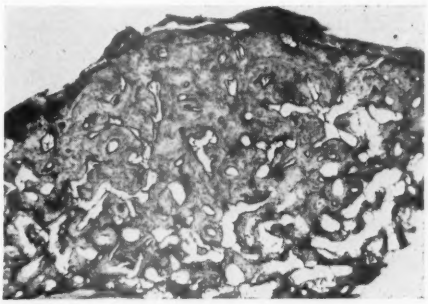


Fig. 2.

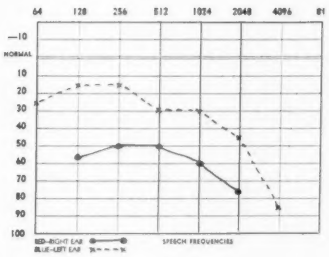


Fig. 3.—3 years postoperative: July 19, 1945.

TABLE I.

CLASSIFICATION	2086 CONSECUTIVE FENESTRATION OPERATIONS	61 CASES WITH OTOSCLEROSIS OF HORIZONTAL SEMICIRCULAR CANAL
A Ideal	64.5%	47.6%
B Suitable	22.9%	26.2%
C Borderline	12.6%	26.2%

To determine the incidence of otosclerosis of the horizontal semicircular canal, the operative notes of the 2,086 consecutive fenestration operations performed at Northwestern University between July, 1938, and December, 1948, were reviewed. A circumscribed focus of pathologic bone in the osseous canal was encountered in 61 cases or 2.9% of all the operations. Since typical otosclerotic bone was found in the three cases biopsied, we believe it is safe to assume that in all of these the pathologic bone was otosclerotic. The size of the focus was noted as small, and not extending through the endosteal layer of bone to the endosteal membrane of the labyrinth, in 22 cases (37.7%). In some of these the focus could be removed entirely (as seen through the operating microscope), in enchondralizing the fenestra.

In 39 cases (62.3%) the focus was larger and reached the endosteal membrane. The latter was nearly always thickened where it lay against the pathologic bone. It is striking and noteworthy that although many of these larger foci protruded into the attic as an exostosis, in not a single case was the lumen of the perilymph space encroached upon. In other words the endosteal membrane appeared to act as a very effective limiting membrane, barring invasion of the lumen of the labyrinth.

Many of these larger foci were clearly extensions from the primary focus at the site of predilection. Some of the smaller foci, on the other hand, seemed to be quite separate from the focus causing ankylosis of the stapes.

The relation of otosclerosis of the horizontal semicircular canal to cochlear nerve involvement was then studied.

As described elsewhere[3] all candidates for fenestration are classified preoperatively according to the degree of cochlear nerve involvement as A (Ideally suited for fenestration) with no nerve involvement for the three speech frequencies, or as B (Suitable, but

TABLE II.

HEARING RESULTS ONE YEAR AFTER OPERATION

	Hearing Gain of 15 db or more	Average Gain in These	Hearing Gain or Loss of Less than 15 db	Average Gain in These	Hearing Loss of 15 db or more	Average Loss in These
231 Unselected Cases	207 (29.6%)	+24 db	23 (10.0%)	+8 db	1 (0.4%)	−34 db
44 Cases with Otosclerosis of Canal	28 (63.7%)	+16 db	15 (34.1%)	+1 db	1 (2.3%)	−15 db

HEARING RESULTS TWO YEARS AFTER OPERATION

	Hearing Gain of 15 db or more	Average Gain in These	Hearing Gain or Loss of Less than 15 db	Average Gain in These	Hearing Loss of 15 db or more	Average Loss in These
231 Unselected Cases	207 (89.6%)	+23 db	23 (10.0%)	+8 db	1 (0.4%)	−43 db
29 Cases with Otosclerosis of Canal	21 (72.4%)	+21 db	7 (24.1%)	+5 db	1 (3.7%)	−20 db

HEARING RESULTS FIVE TO EIGHT YEARS AFTER OPERATION

	Hearing Gain of 15 db or more	Average Gain in These	Hearing Gain or Loss of Less than 15 db	Average Gain in These	Hearing Loss of 15 db or more	Average Loss in These
231 Unselected Cases	207 (89.6%)	+24 db	23 (10.0%)	+7 db	1 (0.4%)	−31 db
7 Cases with Otosclerosis of Canal	3 (42.9%)	+24 db	4 (57.1%)	+9 db	— —	— —

not ideal) with nerve degeneration for 2048, or as C (Borderline) with nerve degeneration for 2 or all 3 of the speech frequencies.

Of the total series of 2,086 consecutive fenestrations 64.5% were A, 22.9% were B and 12.6% were C cases (Table I). Of the 61 cases with otosclerosis of the semicircular canal, 47.6% were A, 26.2% B and 26.2% C cases. Thus early to moderate cochlear nerve involvement is present more than twice as often when the horizontal semicircular canal is involved in otosclerosis, than when it is not so involved.

To learn the relation between otosclerosis of the semicircular canal and the results of fenestration, the 61 cases were studied and compared with 231 cases that had been followed for 5 to 8 years after surgery. In 7 cases with otosclerosis of the semicircular canal audiograms were available 5 to 8 years after operation. In 29 cases audiograms were available 2 years after operation, while in the remaining 44 cases only the one year audiogram was available. In each of these three groups, it is seen (Table 2) that the initial (one year) hearing result was slightly inferior to the average result in the 231 unselected cases, but the two year average result was approximately the same as the one year group. This suggests that closure of the fenestra did not appreciably alter the results between the first and second postoperative years.

COMMENT

Otosclerosis of the osseous horizontal semicircular canal is an occasional finding during the fenestration operation. It is seen more frequently in cases with some cochlear nerve involvement, suggesting that the more extensive the otosclerotic bone lesion, the more likely is the nerve to degenerate.

The prognosis following fenestration is slightly poorer when a focus is found in the semicircular canal, probably because of the greater nerve involvement in these cases.

The observation that the endosteal membrane is an effective limiting membrane to osteogenic encroachment on the lumen of the canal may be made use of to help to prevent closure, by "endosteum-hemming" of the fenestra. In this technic the endosteal membrane from the mouth of the fenestra is folded over the sharp knife-like edges of the completed fenestra, to insure contact with the periosteum of the flap, and primary healing of the cut bone edge. The endosteal membrane hemming the margins of the fenestra acts as a limiting membrane helping to prevent osseous closure.

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AWARDS

THE DE ROALDES MEDAL

The DeRoaldes Medal of the American Laryngological Association was awarded May 9, 1951 to

ARTHUR W. PROETZ, M.D.
St. Louis

THE NEWCOMB AWARD

The Newcomb Award of the American Laryngological Association was given May 9, 1951 to

JOHN D. KERNAN, M.D.
New York

Scientific Papers of the American Laryngological Association

XXXVII

PRESIDENT'S ADDRESS

MEDICAL PROGRESS

GORDON B. NEW, M.D.

ROCHESTER, MINN.

INTRODUCTION

During my forty years of professional life, I have had the privilege of observing remarkable strides in laryngology, attainments which have changed this phase of medicine from a somewhat crude to an accomplished medical specialty. Moreover, it has been my good fortune to have enjoyed a friendly acquaintanceship with a very large number of physicians who have made possible these advances, many of which were effected by fellows of our own society as recorded in the "Transactions of the American Laryngological Association." Familiarity with these men who have accomplished so much for our specialty has convinced me that the individual who does not keep abreast of the trends and discoveries in all fields of medicine but who confines his mental activities to the narrowness and limitations of his own specialty seldom conceives anything new. On the other hand, the specialist who maintains interest and a critical insight into all phases of medicine is the one most certain to produce a praiseworthy contribution. The latter person is likely to obtain an idea from some source extraneous to his own specialty, and then has the ingenious ability to appropriate this idea to his own use, changing it and experimenting with it until a new and effective concept or technic is developed for his own field of endeavor. I would like, therefore, to suggest to the younger fellows of this organization that the more earnestly they seek to cultivate a greater breadth of view in all aspects of medicine, the more likely it is that they will make commendable contributions in the field of laryngology.

How can one broaden his view of general medicine? This can be accomplished in no other way than by continually surveying the general medical literature and by attending state and national medical assemblies as well as the individual's own hospital staff conferences. Not infrequently, at such meetings, a physician may learn of some advance in medicine which can be applied to his own field, or he may be inspired to do an investigative piece of work that may bring forth a truth which otherwise might never have been disclosed.

Some of the most important scientific advances in laryngology are indebted to other fields of medicine for discoveries which directly or by modification have brought forth great improvement in methods of therapy for treating laryngologic disease. It is a few of these discoveries and advances outside of our specialty which laryngologists have appropriated to their own use that I would like to review here. I do not intend to imply that these contributions are not familiar to all of you, but, nevertheless, they are worthy of emphasis.

BACTERIOLOGY

New mycotic diseases have been discovered in the last thirty-five years. In 1906, Darling discovered histoplasmosis, but only in the last ten years has it become recognized clinically and bacteriologically. The lesion is of interest to us as it simulates tuberculosis and, at times, a malignant lesion in the mouth. Ulceration is present which is sometimes multiple. Some of the ulcers remain chronic and involve other parts of the body. There is no specific treatment.

Coccidioidal mycosis, a disease of the South West and of South America, is seen from time to time in the Middle West. The patients have ulcers in the mouth with destructive lesions of bone. The original lesion is pulmonary and may heal or become disseminated. Suppurative proliferated granulomas may be present anywhere in the body.

Actinomycosis is a disease which has been seen for many years in the Middle West. A great deal has been done by the bacteriologist in the study of the disease, first in distinguishing it from infection due to Nocardia; second in developing the ability to grow Actinomyces, and third in testing the organisms, obtained from a patient, in a test tube against penicillin in order to determine whether the particular strain will be affected by treatment.

PATHOLOGY

In 1905 Dr. Louis B. Wilson brought out the use of the fresh frozen section diagnosis for cancer at the time of the operation to determine not only the type of tumor and its activity but also to ascertain whether the tumor has been removed widely enough. This method of making a microscopic diagnosis at the time of the operation has aided greatly in the end results of the treatment of cancer.

In 1913, Dr. William C. MacCarty reported 3 different degrees in the development of cancer of the breast by cytologic diagnosis. This, as far as I know, was the first time that cancer was diagnosed in this way.

In 1920, Dr. A. C. Broders brought out the grading of cancer, depending on the number of mitotic figures present. With this method, he divided cancer into 4 groups. This has been a great aid in determining not only the most efficient treatment for the patient but also the prognosis, depending on the activity of the tumor. In 1932, he also brought out what he called "epithelioma in situ." Here again is a cytologic diagnosis of early cancer before it has broken through the basement membrane. This was another advance in allowing the wide removal of early cancer.

The examination of the sputum and bronchial secretions using the cytologic method of determining the presence of cancer, while not 100 per cent reliable in all cases, has been very useful many times in establishing a diagnosis in certain cases.

These advances in pathology that I have outlined have been applied to our specialty by teamwork, and are a great aid in the treatment of malignant diseases.

HEMATOLOGY

A great deal has been done in the way of advancement with regard to blood dyscrasias and the use of blood in hemorrhage and shock.

The risk of operation can almost be eliminated in pernicious anemia with the use of liver extract or vitamin B_{12}.

In chronic leukemia, a diagnosis by examination of blood and blood smears will sometimes establish a cause of an ulcer of indeterminate origin, and, when roentgen rays and radiophosphorous are used

preoperatively, it allows the patient to undergo operation without added risk.

If the bleeding time and clotting time of a patient's blood are found to be low by preoperative examination, surgical complications may be prevented by having these brought up to normal before operation. Prolonged bleeding time may mean difficulty in many factors. Blood transfusions eliminate some of them, but other agents may be used in certain types of prolonged bleeding.

Agranulocytosis, which was unknown many years ago, is cleared up with transfusions and antibiotics such as penicillin, which are used to protect the body until the leukocyte count returns to normal.

Since 1922, purpura haemorrhagica can be eliminated by splenectomy and thus allow any necessary operation that has to be done.

The establishment of blood banks of citrated blood and plasma and their use in shock and hemorrhage has saved the lives of many patients.

Grouping of blood donors has eliminated the reaction that occurred in the earlier transfusions. Determining the Rh factor is a more recent advance, but is of great value in protecting patients who are to receive transfusions of blood.

DIABETES

Banting's discovery of insulin thirty years ago has changed entirely the care of diabetes. It is one of the milestones in the care of diabetic patients requiring operation. The surgeon is called on to perform many more operations on diabetic patients than formerly because the diagnosis of diabetes is more frequently made and the lives of these patients are prolonged allowing surgical conditions to develop or be acquired. Because of the improved care of patients with diabetes, there has been a marked reduction in surgical mortality, permitting the performance of more elective operations. Wilder said that, since the discovery of insulin, diabetes can no longer be considered the grounds for denying the patient the benefits of operation.

CHEMOTHERAPY

Ehrlich, when he discovered 606, dreamed that all infectious diseases would be treated individually by some specific drug. Much

has been accomplished since then along this line by the use of antibiotics.

Twenty years ago, hemolytic streptococcic infections of the throat were the cause of so-called blood poisoning, and death frequently resulted. The discovery of sulfanilamide and the discovery of penicillin by Fleming in 1929 have changed the whole problem of the treatment of such infections. Now, one rarely sees diffuse cellulitis, lymphangitis and suppurative phlebitis of the neck which caused obstruction of the pharynx or larynx and necessitated tracheotomy and later drainage.

Diffuse staphylococcic infections of the face and neck, including septicemia, which frequently resulted in death, are now controlled by penicillin or one of the newer antibiotics.

Bacitracin is effective locally in mixed infections in which sulfonamide drugs and penicillin have been impotent.

Postoperative pneumonitis of pneumococcic origin may now be treated with penicillin or aureomycin. In meningeal involvement by the Diplococcus pneumoniae, a combination of chemotherapeutic agents produces the best results. Aureomycin has been effective in the treatment of virus pneumonia.

The elimination, to a large extent, of infection by the use of antibiotics in major operations on the larynx has aided in reducing the operative mortality rate to almost zero.

Actinomycosis, a rather common disease in the Middle West, was formerly treated by roentgen rays and repeated drainage with large drainage tubes to try to influence the anaerobic infection. At the present time, penicillin given in doses of one million units a day for three weeks has cleared up the maxillo-facial actinomycosis with involvement of the neck in the cases that I have seen. It is essential that the organism be tested against penicillin to make sure that it is not resistant to this drug.

In some instances, tuberculous patients have been greatly benefitted by streptomycin, and the laryngeal involvement in many cases has been completely cleared up, which improves the outlook for these patients.

The use of penicillin has not only cleared up many of the active lesions of syphilis that one used to see but it has prevented the de-

velopment of the neurologic sequelae that were so common and which filled many of our asylums.

In a public health measure, the employment of toxin-antitoxin in the immunization of children against diphtheria has practically eliminated this dreaded disease that in my earlier days caused paralysis of the palate or laryngeal obstruction. At times, tracheotomy was necessary and many of the patients died even when diphtheritic antitoxin was used.

THERAPEUTIC RADIOLOGY AND OTHER ELECTRIC AGENTS

Therapeutic radiology has been used for a little more than forty years. At first, radium was the chief agent of interest. With the development of high voltage roentgen rays thirty years ago, roentgen therapy has been used for neoplasms at some depth in the tissues. If irradiation is used in cases in which the surgeon feels that this is the best type of treatment, or, if the patient is treated by operation and irradiation, he receives the best possible care. Active types of malignant lesions, even when associated with involvement of the lymph nodes, have been treated successfully with fractional doses of roentgen rays and radium. The selection of the most efficient method of treatment of malignant lesions at times, with roentgen therapy or interstitial irradiation has been a great advance. However, I wish I could say the same for all cases in which therapeutic radiology is used. When one sees patients that have been treated by therapeutic radiology with a poor end result, and realizes that they could have been much better treated surgically, his enthusiasm is curbed for this very efficient method of treatment except in selected cases.

The development of other electric agents such as the electrocautery and surgical diathermy constitutes another great advance. In 1891, d'Arsonval first used high frequency currents to transverse the body. It was about thirty years ago that surgical diathermy began to be used to any extent in this country. Thirty-five years ago, sharp resection of the upper jaw was employed in cases of cancer of the upper jaw and maxillary sinus. Few, if any, of the patients who were treated in this manner remained well.

Following this, heated soldering irons and radium were employed. Soldering irons heated by a gas flame outside the operating room and brought in by nurses were used to burn a large opening into the maxillary sinus and destroy the growth through the mouth in the

early treatment of malignant disease. This was originally called "Percy cautery" after Doctor Percy, of Galesburg, Illinois, who used it for destroying cancer of the cervix. It was necessary to use water-cooled retractors to prevent burning of the cheeks and tongue. Radium steel points or tubes were inserted into the depth of the antral pocket. The method was a very crude one, but it was very efficient in the curing of the malignant disease.

Later, large electrocauteries, thumb controlled, were developed, but, again, considerable protection was necessary in order to avoid burning the lips or cheeks.

This method was followed by the use of surgical diathermy. Cumberbatch, Patterson and Harmer in England, Holmgren in Sweden, and Clark in this country were early advocates of this method, which eliminated the possibility of destroying tissues other than the operative field. It has been a great aid in obtaining better results in the treatment of malignant lesions of the nose and throat.

ANESTHESIOLOGY

In the earlier days, ether was the essential general anesthetic. It was a good anesthetic then and it continues to be a useful agent today, but its usefulness used to be hampered by the meager equipment available for its administration. The technic formerly consisted essentially of putting the patient to sleep with ether administered by the open drop method, taking the anesthetic away, then doing the operative work. When the patient woke up, it was necessary to stop the operation until he had been anesthetized again. This sequence was repeated as often as the duration of the operation necessitated. Coughing, vomiting, straining and contamination of the operative field were frequent occurrences.

Major operations on the larynx were performed by opening the trachea and inserting a two-way tracheotomy tube and then pumping in ether through the tracheotomy opening. Occasional complications were the presence of blood and mucus in the trachea. Today, paravertebral block anesthesia has replaced all of this. Refinement in the technic of local and regional anesthesia and the development of methods for adequately blocking the cervical nerves have changed entirely the anesthetic problem of thyrotomy or laryngectomy.

The use of ether by the rectal route was advantageous in that it removed the anesthetist from the operative field but, owing to the lack of control of the anesthetic, it left much to be desired.

In the administration of ether, perhaps the most revolutionary advance came with the introduction of the Magill intratracheal tube, which completely solved the problem of maintaining a patent airway and continuous control of the anesthesia throughout the operative procedure.

Although the use of nitrous oxide, oxygen and ether by the intratracheal route provided excellent anesthesia, some disadvantages were still apparent. The activity of the pharyngeal and laryngeal reflexes necessitated reasonably deep anesthesia even for short operations if adequate relaxation and a quiet surgical field were to be attained. This necessitated using large amounts of ether, which, in turn, meant a prolonged postoperative recovery period, some nauseated patients, and an increased incidence of postoperative complications.

The introduction of intravenous pentothal sodium anesthesia obviated some of these disadvantages, but not all of them. Since pentothal sodium suppresses reflex activities of the pharynx and larynx and provides relaxation only after large doses have been given, many patients continued to sleep for long periods postoperatively. Now, with the introduction of curare as a supplement to the pentothal sodium, relaxation can be attained with much smaller doses of pentothal sodium and the patient's postoperative course has been much smoother, and freer from complicating factors. It is now possible to carry out a large portion of our operative procedures for which general anesthesia is needed by using pentothal sodium and curare anesthesia and by administering oxygen by means of an intrapharyngeal or intratracheal tube, thereby providing well-controlled anesthesia without the need of using inflammable or explosive anesthetic agents.

Methods of maintaining the patient's physical condition before, during and after operation have advanced along with the quality of the anesthetic. The preoperative medication depends on the requirements. The postoperative recovery room, where the patient receives every attention, has added considerably in the patient's comfort and care.

Perhaps the most important feature of the present-day anesthetic management comes from a better understanding of some of the problems of anesthesia by the surgeon and a higher degree of training on the part of the anesthesiologists, resulting in a combination of effort which works to the mutual advantage of the patient, the anesthesiologist and the surgeon.

CONCLUSION

It is my sincere hope that this presentation will serve to emphasize the fact that no outstanding progress can be expected from any specialized group which detaches itself from general medicine. On the contrary, we as laryngologists should welcome every opportunity to investigate all medical advances for material which will be helpful in our own field of endeavor. In no other way can we expect laryngology to continue as a productive vigorous specialty.

MAYO CLINIC.

XXXVIII

VIRAL DISEASES OF THE NOSE AND THROAT

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The advent of chemotherapy and antibiotics has eliminated the severe bacterial diseases of the ear, nose and throat, and in their wake remain the viral infections, many stubborn and persistent. The mode of entrance depends upon the portal; the common cold through the respiratory membranes; poliomyelitis through the alimentary tract, and yellow fever by a bite of a mosquito. The immunity following viral infections varies with the site of the abode. The common cold sets up little or no immunity, whereas blood stream infections such as measles produce lasting immunity.

When Iwanowski[2] and Beijerinck[3] were attempting to filter out bacteria they realized that a certain filterable element escaped. That fugitive element we now know to be virus.

In 1944 Wycoff[4] devised a procedure for shadowing, photographing, and demonstrating the shapes of virus. Today, through crystallization of the combined thoughts in virology, the best answer to what is a virus is that it is a pathogen differing from bacteria in that it inhabits a cell while bacteria usually inhabits tissue fluids. It is filterable by the ordinary earthenware filters, easily destroyed by ultra-violet rays, but resistent to freezing or drying. Francis designates them as obligate intracellular parasites because they are basically cytotropic and they require a living cell for their maintenance and reproduction.

When a virus attacks an individual it penetrates the cell and, unlike bacterial insult, may not produce an inflammation. The cell reaction may range from proliferation to death. The invasion of a virus is perhaps a piggy-back ride on a bacterium and when its mount is destroyed by an antibiotic, the virus remains and enters the cell to carry on its fight. The virus is capable of destroying the bacteria. This ability explaining the action of bacteriophage.

The virus of foot and mouth disease was the first to be isolated. Many have followed, but to the laryngologist the viral diseases of importance are classified according to their locations—the common cold, and Stevens-Johnson syndrome representing the mucous membrane and skin, Herpes laryngis representing the neurotropic and infectious mononucleosis the glandular system.

CULTURES

Few cities in the United States have laboratories capable of isolating a virus. The procedure is time-consuming and expensive. A complement fixation by a virus hemagglutination provides a convenient serological diagnosis. To manufacture a virus vaccine it is necessary to isolate the individual virus. Smith, Andrews and Laidlow[18] discovered that ferrets were susceptible to intranasal inoculation of nasal secretions from influenza patients. Fortunately, a fertilized egg being embryonic furnishes a living cell which will grow a wide variety of the viruses. Our modern anti-virus vaccines for influenzal infections are the result of this knowledge and their administration require protection for those sensitive to egg protein.

VIRUS INFECTIONS OF THE NERVES

Herpes laryngis begins with a neuralgia along the pharyngeal and laryngeal distribution of the 9th and 10th cranial nerves, is followed by a herpes and a prolonged neuritis of months duration. Clinically the herpes are visible on the soft palate, lateral pharyngeal wall and mucous membrane of one-half the larynx. The diagnosis is delayed until the appearance of the herpes zoster. The initial examination may fail to visualize sufficient evidence of pathology to account for the pain and dysphagia. If seen late, the blisters may assume the character of ulcerations. The involvement of the visceral branches of the vagus are manifested by bradycardia hiccups or nausea. McGovern reported a case of a man age 69 with a typical right-sided herpes laryngis.

Herpes zoster of the upper cervical nerves is frequently missed until the presence of the herpes is called to the attention of the doctor. M. E. F., a male aged 54, was admitted to the hospital with an extensive herpes zoster of the right side of the face and scalp. The neuralgia was severe, and he sought the advantages of the baths of Hot Springs, Arkansas. Unfortunately, during his stay the ad-

ministration of one of the barbiturates complicated matters by producing an agranulocytosis.

Ramsey-Hunt syndrome will not be considered as it includes the 7th and 8th cranial nerves and primarily affects the ear.

VIRUS INFECTION OF THE LYMPHATIC GLANDS

The diagnosis of viral infection of the nose and throat is common, especially if the angina is stubborn and resistant to the ordinary remedies. The infection is selective according to the age of the patient. In the young, the upper elements of Waldeyer's ring are invaded; while in the matured the infection lingers in the lower segment.

During the acute stage of the angina there is nothing characteristic to indicate that the infection is viral. Only the persitence of symptoms and the inflammatory state of any and all the lymphoid tissues, including the neighboring glands, suggest the diagnosis. Herpetic lesions in the region are suggestive.

INFECTIOUS MONONUCLEOSIS

The disease is clearly infectious, but the epidemiology is obscure. The infecting agent is a virus, and the disease has been transmitted in monkeys by an agent obtained from bacteria-free nasal washings. The exact mode of transmission is not known, but it seems to be by droplet infection similar to the common cold. Cases may occur sporadically or in epidemic form. The virus is highly infectious, though it resembles other viruses in that the inapparent infection is common. This may explain why some persons exposed to the infection do not contract the disease. The infective period is unknown. One attack probably confers a lasting immunity and reported recurrences are probably due to a similar condition of infectious lymphocytosis or other infections, or to relapses of the original infection. It occurs in all ages, but is most common in children.

The milder cases can be divided into three groups according to the classifications of Tidy: the glandular fever type occurs in children and is characterized by enlargement of the cervical lymph nodes and little inflammation of the throat. The anginoid type occurs in young adults and is characterized by the development of a true mem-

brane on the throat, with enlargement and tenderness of the cervical lymph nodes. There is fever out of proportion to the patient's appearance. The membrane separates within a week, and the patient rapidly improves. The adult type is more insidious, often preceded by a longer incubation period and accompanied by less glandular enlargement and inflammation of the throat. The prolonged fever is most characteristic, but it is difficult to distinguish from other causes of prolonged fever. There is lymph node enlargement, most frequently in the post-cervical chain, and this may be tender. The spleen is palpable in about half of the cases.

Severe cases have been reported complicated by splenic rupture, encephalitis, and other neurologic disorders, hepatitis with and without jaundice, and thrombocytopenic purpura, according to the complication present. These widespread manifestations have been explained by the generalized involvement of the cases which have come to autopsy. Focal infiltrations of mononuclear cells in a number of organs, including the liver, heart, kidneys, lungs, spleen, testicles and brain have been observed.

Diagnosis is made from the clinical course when it is typical, and from the blood when it is not. In the milder forms, there may be an initial leukocytosis, from 15,000 to 20,000 cells with 75 per cent polymorphonuclears. This finding may be entirely misleading if another count is not done. Usually there is a leukopenia of the polymorphonuclear cells from the onset. The abnormal lymphocytes which are characteristic of the disease then appear, with round or bean-shaped nuclei, usually without nucleoli, and with abundant "foamy" cytoplasm which may be folded on itself. These cells are not confined to infectious mononucleosis alone, but are found in a number of other infectious diseases. There is a lymphocytosis for a variable length of time. Difficulties arise in the differentiation from acute leukemia, which usually shows more young forms in the blood and more toxicity, and chronic lymphatic leukemia, the early stages of which closely mimic infectious mononucleosis. The heterophil agglutination test of Paul and Bunnel is helpful in making the diagnosis in all but the most obvious cases. A significant titer varies with the method employed, so will vary from place to place. A positive reaction may occur very early, as in the milder cases, or it may not appear until later with subsidence of the constitutional symptoms, so it is best in suspected cases to repeat the test where it is

negative when first done. A positive test is considered diagnostic, but a negative test does not preclude the diagnosis, since about 10 per cent of these cases fail to show antibodies.

Mumps is a specific virus disease of the salivary glands. In children it is a painful, innocent malady, but adults may suffer serious complications, the worse being nerve deafness.

Enders demonstrated the value of a skin test in diagnosing the infection and in identifying those in need of vaccination. When an adult of doubtful past history, such as a recruit, has been exposed to mumps, a skin test should be made. If the test is negative, an immunizing dose of the combined V. & S. Mumps Vaccine offers a possible prevention of the disease.

STEVENS-JOHNSON SYNDROME

Stevens-Johnson[15] reported in 1922 two instances in which a child had dramatic lesions of the skin and mucous membranes with severe ophthalmological involvement. Their studies failed to isolate the etiological pathogen. Today the symptom complex is considered viral. The onset is usually with a sore throat and accompanying systemic symptoms. The mouth and throat lesions begin with stomatitis and when the eruptions appear on the skin, the clinical picture may become serious. The mucosal ulcerations bleed readily and trismus sets in to limit the future study of the mouth and pharynx. The temperature is of the septic type and proportionate to the lesions. Starting as a simple conjunctivitis, the ophthalmological pathology can go through a purulent stage ulceration and panophthalmitis with loss of vision.

REPORT OF A CASE

F. R., a male aged 53 was admitted to the hospital on March 30, 1949. The patient was well twenty-four hours before admission except for a cough, which he had had for the preceding four days. In the morning on the day prior to admission he developed hiccup, which was quite rapidly followed by blisters in the mouth, which bled easily. During the next twelve hours he developed a full-blown rash on the palms of his hands, feet and penis, which itched, ruptured and bled easily. A conjunctivitis developed the second day of admission. The patient was unable to tolerate his dentures.

The patient was obviously an ill man. A general red erythema covered his neck. There was a mild conjunctivitis with old healed trachoma lesions as evidenced by scars. Nose and ears were negative; there were white pseudo-membranous lesions over the buccal mucosa and the tongue and lips. Some oozed blood.

Chest, heart, abdomen and extremities were negative. The glans penis had similar lesions to those in the mouth. There was herpes on the palms of the hands and the soles of the feet with deep-seated and indurated papules similar to papular syphilid.

Consultation with the ophthalmologist (Charles M. King, M.D.) revealed 1) Old healed trachoma, bilateral. 2) Mild conjunctivitis of each eye, incidental to general epithelial disturbance. 3) Erythema exudativum multiforme (Hebra's Disease).

The dermatologist (Emmett Hall, M.D.) reported typical lesions of erythema multiforme, the etiology of which is unknown. There is no specific treatment except supportive as this is a self-limited disease, usually occurring in the Spring.

The Kline test was negative. R.B.C. 4,420,000; Hb. 13 grams, 84%; W.B.C., 9,550; segmented forms 48; band forms 6; lymphocytes 44 and eosinophils 2.

The urine appeared slightly turbid; albumin was negative; sugar was negative; acetone was negative; reaction was acid; color was straw; sp. gr. 1,023; W.B.C. 10-15 1 Hpf; bacteria few.

Penicillin, 300,000 units daily; Nicotinic Acid, 100 mgm, daily; saline mouth wash and sulfathiazol ophthalmic ointment three times a day constituted the medication.

The lesions of the skin improved faster than those of the mucous membranes and by the fifteenth day the lesions had faded and the dermal areas had exfoliated. Convalescence required two months.

The final diagnosis was Stevens-Johnson Syndrome (erythema multiforme exudativum).

TREATMENT

Once a virus enters a cell it is protected from therapeutic agents. The early administration of the antibiotics and the sulfonamides will cripple a bacterial invasion, but only the patient's resistance can eliminate the virus. Vaccine therapy for virus originated when Jenner prevented smallpox by inoculations. The future control of viral disease will be through vaccine therapy. Our best clinicall results have been obtained by inoculations of 1/3 cc of Influenza Virus Vaccine, Type A. & B. weekly for a month with reinforcement by a suitable tonic.

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XXXIX

TREATMENT OF OSTEOMYELITIS OF THE SKULL RESULTING FROM ETHMOID AND FRONTAL SINUSITIS

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My discussion will be restricted to the treatment of osteomyelitis of the skull resulting from ethmoid and frontal sinusitis. Osteomyelitis resulting from maxillary antrum or sphenoid sinusitis, or from any other cause will not be presented.

Not infrequently patients developing osteomyelitis are poorly nourished. It goes without saying then that their general nutritional status should be improved by the various therapeutic aids at our disposal, the most important of which is a well balanced, high caloric, high carbohydrate, high vitamine, high protein diet supplemented by iron.

Preoperatively, these patients are frequently acutely ill. Chills and fever are common, as well as, severe head pain. The pain can be controlled by cold applications to the region of infection and the administration of aspirin or one of the narcotics.

Since the introduction of the antibiotics, the more severe complications of osteomyelitis have been less frequent. We prefer the use of penicillin and aureomycin preoperatively. At operation, the osteomyelitic pus is cultured and the offending organism accurately established. The sensitivity of this organism to one of the antibiotics is also determined and the proper antibiotic is correspondingly administered in therapeutic doses.

SURGICAL TREATMENT

A. *Prophylactic Operative Treatment of Frontal and Ethmoid Sinusitis* (*External Drainage*). If a patient with sinusitis is under the care of the rhinologist, osteomyelitis of the skull should be a rare complication. Drainage externally of the ethmoid or frontal sinuses

Fig. 1.—Ruptured ethmoid with drainage tube inserted.

would usually be indicated before osteomyelitis would be established, or at least, operative interference would be instituted while the osteomyelitis is in it's incipiency; so that usually only comparatively simple operative procedures would be necessary. If the osteomyelitis is of the very fulminating type, more active procedures would be indicated than in the usual case.

If an ethmoid or frontal sinus is causing symptoms and signs, such as severe pain, high temperature, tenderness and external swelling of the sinuses while under the usual treatment, such as the antibiotics and intranasal medication, then an external drainage of the frontal or ethmoid sinuses, or both should be instituted.

The ethmoid in little children should be drained externally with the insertion of a hard fenestrated rubber tube placed through the ethmoid into the nasal cavity.

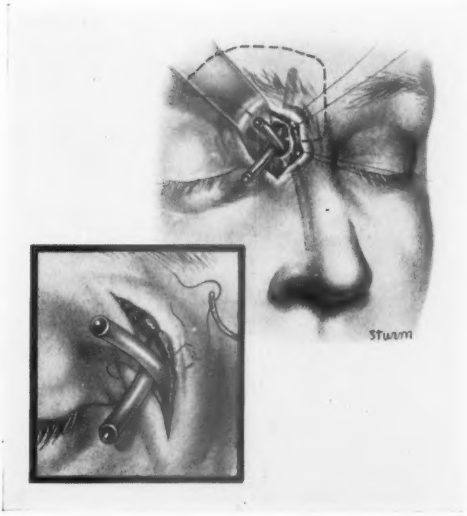

Fig. 2.—Ruptured ethmoid and frontal with drainage tubes inserted.

In adults, a hard fenestrated rubber tube is inserted into the frontal sinus through it's floor, as well as, a second tube through the ethmoid sinus into the nose. A single curved incision well below the brow is adequate. An opening through the bone is easily established with the cutting burr.

No surgery should be done except to establish drainage of the sinuses. The mucous membrane is disturbed as little as possible. The hard rubber tube may be removed in three or four days, or as soon as the temperature becomes normal, pain decreases and other symptoms and signs are markedly decreased. Sutures through the skin edge and through both tubes are necessary. No closure of the wound at the time of the drainage and none at the removal of the tubes is indicated. The above described procedure would usually stop the progress of the sinusitis, or incipient osteomyelitis and prevent the occurrence of a large percentage of the osteomyelitis of the skull.

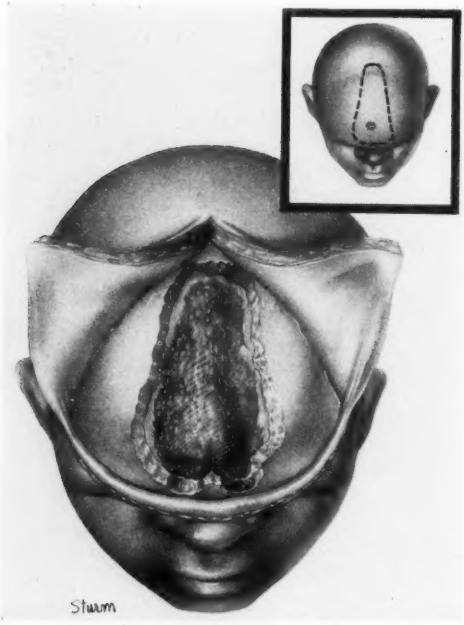

Fig. 3.—Showing extensive pathology of frontal region with T. incisions.

B. *Operative Treatment of Osteomyelitis of the Skull and External Drainage of the Ethmoid and Frontal Sinuses.* If osteomyelitis of the skull, as a result of infection in the ethmoid and frontal sinuses is already established when seen by the rhinologist, the signs and symptoms, such as pain, swelling, tenderness and redness of the frontal region are usually present. Only in the exceptional extensive progressive cases is the parietal or occipital region involved. In the early osteomyelitis of the frontal region the x-ray may not indicate as much pathology as really exists. After osteonecrosis has taken place, the x-ray would show pathology. The edema and tenderness are more reliable signs than the x-ray findings. The x-ray would always indicate disease of the offending sinuses and with the symptoms and signs as indicated above in the frontal region an immediate drainage of both the ethmoid and frontal sinus is indicated,

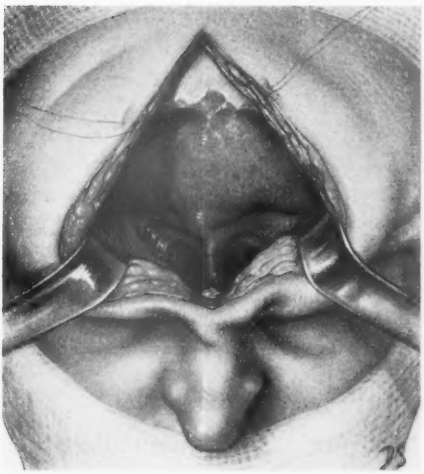

Fig. 4.—Medial line exposure in ostemyelitis of frontal with exenteration of frontal sinuses and surrounding bone.

followed immediately by the operative procedure on the frontal area. A simple drainage of the frontal and ethmoid as described above is carried out, followed by a wide exposure of the osteomyelitic area of the frontal region. Usually a vertical incision in the mid-line extending well towards the hair line is made connecting with a horizontal incision on one or both sides, well above the brow. The periostium is usually off of the osteomyelitic area. The flap of the soft tissues is retracted upward and outward. If both frontal regions are diseased, two flaps are made, one on each side. The entire questionable area should be exposed. Bone with normal adherent periostium is usually uninvolved and may be left with safety. However, extension of the osteomyelitis into the medullary spaces beyond this point must be accurately determined.

The diseased bone may be removed with the gouge, chisels, rongeurs, or cutting burr. It seems to me the initial opening in the bone can well be done with the motor cutting burr. If there is an opening in the cortex which there often is, removal of bone can be begun in this area. A wide opening into the superior part of the frontal sinus should be made if it is not spontaneously present. A wide

removal of all questionable bone is indicated, including outer and inner tables. Occasionally a small localized area immediately around the frontal sinus may be the only pathology, and no further operative procedure would be necessary than it's removal. Too little removal of diseased bone is dangerous. To leave the internal table intact with an epidural or brain abscess within, would often be fatal. Complete removal of all diseased bone with as little trauma to the dura and brain as possible, is the ideal. If the osteomyelitis is complicated by a brain abscess or meningitis, adequate draining of the area must be established. The entire area is packed wide open. No closing sutures are indicated.

The progress of the osteomyelitic area can be more easily followed than if any partial or complete closing of the wound is carried out. It seems to me that immediate closing of the wound endangers the life of the patient to a marked degree.

If there is any further progression of the osteomyelitis, operative interference can be instituted at any time through the open wound.

C. *Exenteration of the Ethmoid and Frontal Sinuses.* As the osteomyelitic process originated from an infection in the frontal or ethmoid sinuses, it seems to me that the best procedure to prevent subsequent infections in the sinuses with a possible recurrence of the osteomyelitis would be a thorough meticulous exenteration of these cavities. Therefore, if there has been no evidence of osteomyelitis for four to six weeks, the complete and final operative procedure on the ethmoid and frontal sinuses should be done. The initial operative wound of the ethmoid and frontal sinuses below the brow is re-opened, and the exenteration of these cavities is completed. The frontal can also be very satisfactorily approached from the frontal opening above as the superior portion of the frontal sinus was opened at the initial operation on this area.

The ethmoid and frontal areas are completely exenterated of all mucous membrane and all septae. The motor burr facilitates this procedure very much. All bony projections should be taken down with the burr. All extensions of the frontal can be directly visualized from the superior approach. The entire frontal and ethmoid area should be cleansed of the mucous membrane and polished with the burr. Very little, if any packing is used in the ethmoid and frontal regions and the external wound of the ethmoid and frontal below the brow is closed with silk.

PLASTIC RECONSTRUCTION OF THE OPERATIVE DEFECT

After the osteomyelitic wound has been observed for several weeks and after a reasonable time has elapsed after the complete exenteration of the ethmoid and frontal sinuses, if there are no symptoms of recurrence of the osteomyelitic process, the frontal flap, or flaps should be lifted up and the entire osteomyelitic area closed.

The bone defect may be partially or almost completely closed by new bone; the new bone formation will usually be more complete, the younger the patient. If the wound is depressed or if there is unsatisfactory new bone formation, any defective area may be improved by the insertion of bone chips, tantalum plates, bone grafts, etc. This procedure should not be done until there has been no evidence of osteomyelitic extention for one to two years. It seems to me that the insertion of bone chips taken from the iliac crest is the most satisfactory.

SUMMARY

1. Drainage of frontal or ethmoid sinuses with symptoms and signs such as marked pain, tenderness, external swelling, fever, etc., will often abort impending osteomyelitis.

2. Adequate removal of osteomyelitic bone of the frontal region without closure of the wound is the procedure of choice.

3. Complete exenteration of the frontal and ethmoid sinuses after symptoms of osteomyelitis have subsided is basic, and should be done in all cases.

4. Plastic closure of the frontal area is done only after sufficient time has elapsed to insure that there will be no further osteomyelitis.

5. Bone defects are corrected by the use of bone chips or other media.

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XL

CEREBRAL VENOUS THROMBOSIS

ITS OCCURRENCE; ITS LOCALIZATION; ITS SOURCES AND SEQUELAE

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AND

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In the course of nasal sinus and middle ear infections, supervening signs of focal cerebral involvement are usually indicative of brain abscess.[53, 25, 93, 5]

There are, however, certain instances when brain abscess is strongly suspected because of signs of focal cerebral involvement but is not found on surgical exploration or demonstrated by contrast roentgenography, and, the clinical course reverses toward recovery.

Adson[1] believed that, in this type of case, the infection extended into the brain but resolved without suppuration. He called the condition pseudo-brain abscess. Others have referred to it as acute non-suppurative encephalitis, or local non-suppurative meningitis.[67, 87]

Our interest in this problem was aroused by three patients (Cases Nos. 3, 4 and 5) who presented themselves within a single year. They were remarkably alike in that they developed, in the course of paranasal sinus infection, focal seizures, hemiparesis and signs of meningeal irritation. They were strongly suspected of having abscess but appropriate investigation ruled otherwise, and, they recovered without the necessity of intracranial exploration. We can only speculate on the cause of the neurological signs.

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Because of the transitory nature of the disabilities it seemed reasonable to ascribe the cause to a vascular disturbance. Moreover, because of the cortical locus of the lesion and the unlikelihood of arterial embolus the vascular accident was judged to be in the superficial cortical veins. A presumptive diagnosis of superficial cerebral venous thrombosis was made.

In search for similar cases, the records of the Royal Victoria Hospital and the Montreal Neurological Institute, covering a twenty-five year period, were reviewed. We sought to substantiate the diagnosis by verified material but found only three cases which came to autopsy, when, the presence of cortical venous thrombosis was confirmed. Ten other cases were found in which the diagnosis was made; intracranial operation was performed on three, but, thrombosis of cortical veins was not described at operation. Four more cases showed cortical venous thrombosis at operation or autopsy but in association with brain abscess.* We have currently under observation in hospital, four other patients in whom this diagnosis seems clinically applicable but in whom surgical intervention has not been justified.

We have concluded, from studies of our material, that there is a clinical syndrome characterized by evidence of localized cerebral involvement manifested by focal palsies, and, frequently by seizures.

We are of the opinion, from our own experience and from evidence in the literature, that cerebral venous thrombosis or thrombophlebitis is a reasonable explanation for the syndrome and that it may occur in divers disorders, as a complication of nasal sinus and middle ear disease, pulmonary disease, puerperal disease, or may occur from unknown causes. We admit other explanations for the syndrome as in certain disseminated vascular diseases.

A review of our case material follows.

INFECTION ORIGINATING IN PARANASAL SINUSES

(Eight Cases)

CASE 1.—A thirteen year old boy was admitted to the Royal Victoria Hospital in 1932 (Dr. Wilder Penfield and Dr. W. J. McNally). Two days before admission he had been swimming after which he developed a fulminating infection in the left frontal sinus. He had a septic temperature, was toxic, drowsy and

*This material will be discussed in a subsequent paper dealing with brain abscess.

apathetic. There was weakness of the right lower face; the right knee jerk was increased. Surgical drainage of the left frontal and ethmoidal sinuses was performed at once. Pus yielded staphylococcus aureus. The abnormal neurological signs disappeared in twenty-four hours. Temperature subsided by lysis in five days. Blood cultures were sterile. Three and a half weeks later signs of disturbance in the left cerebral hemisphere reappeared; the right ankle jerk was exaggerated and the right superficial abdominal reflexes were absent. One week later following removal of osteomyelitic bone from the left supraorbital ridge he began to recover. He was discharged from hospital five weeks later when the abnormal neurological signs had again disappeared. He did not receive chemotherapy. There has been no recurrence in nineteen years.

The neurological signs in this patient were indicative of temporary impairment of the long motor system in the left cerebral hemisphere.

CASE 2.—An eighteen year old boy was admitted to the Royal Victoria Hospital in 1933 (Dr. J. T. Rogers and Dr. W. V. Cone). One week earlier he had been swimming and had developed painful swelling about the right eye. On admission the movements of the right eye were severely limited by periorbital swelling and proptosis. He had a septic temperature with chills and sweats and developed numerous skin pustules. Immediate operation revealed a periorbital abscess and purulent infection in the right frontal, ethmoidal and maxillary sinuses. Cultures from the sinuses grew staphylococcus aureus. A blood culture was negative. On the third post-operative day he had a seizure involving the left hand and arm immediately followed by clonic movements of the right hand, arm, face and body. Weakness of the left lower face followed and there were intermittent twitchings of both eyelids and muscles of all limbs for several days. He did not receive chemotherapy, nevertheless recovery was rapid and when last heard of in 1946 he had been well.

The signs suggested that there were multiple lesions in the cortex of both hemispheres and perhaps in subcortical centres as well.[70]

CASE 3.—A woman of fifty-four years was admitted to the Montreal Neurological Institute in 1948 (Dr. Wilder Penfield and Dr. E. A. Stuart). Ten days earlier she developed a cold followed by headache, malaise and bilateral earache, for which she received intramuscular penicillin. Her speech was incoherent; she was unable to move her right hand; drowsiness increased to semi-coma and her neck became stiff.

On admission she had right hemiparesis most evident in the arm and face. She was aphasic. Both plantar responses were extensor; the superficial abdominal reflexes were adbsent. A seizure was observed which began with movements of the right side of the face and right arm. The spinal fluid pressure was 330 mm.; the fluid contained 1520 w.b.c. and was sterile. X-rays of the skull showed evidence of pansinusitis. Penicillin therapy was continued throughout hospitalization. Bilateral external fronto-ethmoidectomy was carried out. Pus contained micrococci and bacteroides. She improved generally following operation. A week later ventriculography was negative. Eleven days after admission she showed slight residual weakness of right arm and right face, and some aphasia.

Nine months later she had two short seizures involving only the right hand. Because of this she was readmitted and found to have slight weakness of the right arm. A pneumoencephalogram revealed some dilatation of the ventricular system.

There have been no recurrences to 1951 but she has been controlled on small doses of anti-convulsant medication.

This patient had some evidence of meningitis. She had hemiparesis especially of the face and upper limb. She has required anti-convulsant medication because of recurrent though infrequent focal epileptic attacks.

CASE 4.—An eighteen year old boy was admitted to the Montreal Neurological Institute in 1948 (Dr. W. V. Cone and Dr. E. A. Stuart) because of the occurrence of two epileptic seizures in the course of acute frontal sinusitis, which had begun twelve days before. External drainage of the right frontal sinus had been carried out elsewhere nine days previously, and, he had been receiving penicillin.

On admission he was stuporous. The neck was stiff. There was astereognosis in the left hand. The spinal fluid contained eight lymphocytes; the pressure was 350 mm. There was evidence of pansinusitis on the left side and frontal sinusitis on the right. Penicillin therapy was continued. Bilateral external, frontal ethmoidal, sphenoidal and left antral sinus drainage was carried out. He improved rapidly and was discharged on the seventeenth hospital day. In 1951 he reported that he had been well.

A focal cerebral lesion was manifested by seizures arising in the hand area of the left motor strip and by astereognosis in the hand. Both of these signs are indicative of a cortical lesion.[38]

CASE 5.—A seventeen year old boy was admitted to the Monteal Neurological Institute in 1948 (Dr. A. R. Elvidge and Dr. E. A. Stuart), with a tentative diagnosis of brain abscess. Five days before admission he had developed severe headache in the course of a cold which had been present for three weeks. He had vomited repeatedly and had had several convulsions.

On admission he was stuporous. There was evidence of left pansinusitis. The neck was stiff and Kernig's sign was present. The spinal fluid pressure was 260 mm and there were 600 w.b.c. in the spinal fluid. Cultures of blood and spinal fluid were sterile. A pneumoencephalogram was normal. Immediate external drainage of the left frontal and ethmoidal and antral sinuses was performed. Pus yielded anaerobic micrococci and diphtheroids. He had intensive penicillin and sulfonamide therapy.

After operation he continued to be confused; he became aphasic and developed a flaccid paralysis of his right hand. The neurological signs diminished in spite of a persistent septic temperature and within ten days of admission he developed signs of extensive thrombophlebitis of both legs. Recovery was gradual. He was discharged at the end of three months.

In 1950 his family reported that he had had bi-monthly epileptiform attacks now controlled by medication.

This patient in addition to seizures had had aphasia, and, paralysis of the right hand. The seizures have tended to recur. The widespread thrombophlebitis is noteworthy.

CASE 6.—A fifteen year old boy was admitted to the Royal Victoria Hospital in 1933 (Dr. G. E. Tremble and Dr. W. V. Cone). He had been ill for three

weeks with a cold and had developed a severe infection in his right frontal sinus. Cultures from his nose contained staphylococcus aureus and hemolytic streptococci.

On admission he had a stiff neck. Kernig's sign was present. Spinal fluid pressure was 260 mm (350 w.b.c.) and remained elevated for several weeks. External drainage of the right frontal and ethmoidal sinuses was established. The patient became comatose and showed left lower facial weakness and Babinski's sign.

The right cerebral hemisphere was explored for abscess on two occasions with negative results. A seizure occurred involving only the left arm; a left hemiparesis followed. Two days later a second seizure occurred which began in the left side of the face and spread to the left arm.

Recovery was gradual. When discharged two months later he was hemiparetic on the left side. The weakness was more in face and arm, and, least in leg.

Despite treatment he has continued to have occasional focal seizures to 1951; the hemiparesis has disappeared.

CASE 7.—A boy four and a half years was admitted to the Montreal Neurological Institute in 1944 (Dr. W. V. Cone). Two months earlier he had developed an upper respiratory infection, fever, and pain over the left side of the nose. Two weeks before admission he could not move his left leg. Movements of both eyes became impaired and a soft fluctuant swelling appeared over the right eye. On admission there was almost complete right external ophthalmoplegia, and weakness of outward and downward rotation of the left eye. There was bilateral papilloedema. There was flaccid left hemiplegia with ankle clonus and Babinski's sign. There was clinical and x-ray evidence of sinusitis and osteomyelitis of the frontal bone.

He was given intensive penicillin therapy. The infected bone was removed from the frontal region and subdural abscess was encountered. The superior longitudinal sinus was opened and found to be filled with purulent thrombus from its anterior limit well back toward the parietal eminence. Cultures contained streptococcus hemolyticus. The child did not survive; autopsy was refused.

In this case there was evidence of continuity of infection from frontal osteomyelitis to the superior longitudinal sinus.

CASE 8.—A ten year old boy was admitted to the Montreal Neurological Institute in 1949 (Dr. W. V. Cone). Ten days before admission he developed a head cold with headache and swelling of the face. In the two days prior to admission he had fifteen generalized seizures. On admission temperature was 104 degrees; he was comatose. There was no papilloedema. Spontaneous movements were observed only in the right limbs. There was clinical and x-ray evidence of bilateral antral sinusitis. Intensive penicillin therapy was administered.

There was an unobserved seizure after which the left arm was flexed and spastic. A second seizure followed which began in the right arm and quickly became generalized. The spinal fluid pressure was 300 mm. There were no cells in the spinal fluid. The seizures ceased and the left hemiparesis recovered in three days.

There has been no recurrence of symptoms to 1951.

INFECTION ORIGINATING IN THE MIDDLE EAR

(Four Cases)

CASE 9.—A nine months old boy was admitted to the Royal Victoria Hospital (Dr. H. E. McHugh and Dr. A. R. Elvidge) in 1946 with bilateral otitis media. The infant had been ill for a week. Paracentesis was performed on both ears immediately. Pus contained hemophilus influenzae. Intensive penicillin, streptomycin and sulfonamide therapy was administered. The next day there was a series of seizures, involving the left face and limbs together with clonic deviation of the eyes to the left. He became comatose. Temperature was septic: 104 degrees. Both mastoids were drained. The temperature fell by lysis. The spinal fluid pressure was 400 mm. Cultures of the spinal fluid yielded hemophilus influenzae and staphylococcus aureus. Ventriculogram was negative. He had a second series of seizures consisting in twitching of the muscles of both sides of the face, both arms and the left leg.

Recovery was gradual and complete. Recent information has not been forthcoming.

CASE 10.—A female aged ten months was admitted to the Montreal Neurological Institute in 1948 (Dr. W. V. Cone). Focal seizures and a left hemiparesis had occurred three weeks earlier during bronchopneumonia. Temperature was 105 degrees. There were seizures, generalized at first, and, finally localized to the face and left arm. One week later there was left hemiparesis.

There was bilateral acute suppurative otitis media. Death occurred forty-eight hours after admission. At autopsy there was extensive thromboplebitis of all the venous sinuses and numerous cortical veins. The cerebral hemispheres were haemorrhagic and softened.

CASE 11.—A four year old boy was admitted to the Montreal Neurological Institute in 1944 (Dr. F. L. McNaughton). In the previous week he had developed increasing lethargy with spasticity of the left limbs and choreiform movements of the right limbs. Facies was mask-like; he was drooling. He appeared to have visual hallucinations. The spinal fluid pressure was 350 mm (12 lymphocytes). Pneumoencephalogram did not show a space occupying lesion.

Shortly after admission he had a generalized seizure. Decerbrate rigidity developed and death followed after three weeks.

Autopsy showed pus in both middle ears and mastoids. Thrombosis of the left lateral sinus, the superior longitudinal sinus, bilateral frontal and parietal cortical veins and thrombosis of both iliac veins were present. There was embolism of the pulmonary artery. There was cortical and subcortical haemorrhagic softening in the left cerebral hemisphere. See Figs. 5, 6, 7, 8.

CASE 12.—A woman of forty-one years was admitted to the Montreal Neurological Institute in 1946 (Dr. Wilder Penfield). Four months before admission she had had pain and discharge from her left ear. Later she developed intermittent pain over the left eye. She had two seizures in which she suddenly stopped talking, assumed a staring expression and walked about in an aimless manner with twitching of both arms and legs. Aphasia followed. She received intensive penicillin therapy.

The visual fields were normal. The spinal fluid pressure was 400 mm. There were no cells in the spinal fluid. X-rays showed increased density in the left mastoid process and a shift of the pineal gland to the right. Ventriculogram indicated a space occupying lesion in the left temporo-parietal region.

On exploration haemorrhagic softening was found within the temporal lobe. Recovery was gradual.

This patient showed classical signs of a temporal lobe abscess complicating chronic otitis media but on exploration abscess was not found. This is typical of the cases described by Adson.[1] We have interpreted the lesion to be a venous infarct.

In spite of anti-convulsant treatment she has continued to have seizures up to 1951.

INFECTION ORIGINATING IN THE LUNG

(One Case)

CASE 13.—A twenty-two year old woman was admitted to the Montreal Neurological Institute in 1950 (Dr. A. R. Elvidge and Dr. C. A. McIntosh). Four weeks before admission a right pulmonary lobectomy was performed for chronic atelectasis in the course of quiescent tuberculosis. Shortly after operation she complained of numbness and burning sensations in the right side of the face with headache and disturbance of vision. She became restless and confused. She had six undescribed seizures within forty-eight hours.

On admission she was semi-comatose, aphasic, and, had weakness of the right lower face and arm. The spinal fluid including guinea pig inoculations was negative for tuberculosis. Pneumoencephalogram was negative.

Two days after admission the neurological signs subsided and have not recurred.

Sometime later pulmonary tuberculosis became reactivated and is presently being treated.

The neurological signs indicated a transient focal lesion in the left motor area.

ORIGIN UNKNOWN

(Two Cases)

CASE 14.—A four year old boy was admitted to the Montreal Neurological Institute (Dr. Colin Russel and Dr. E. A. Stuart) in 1939 because of weakness of the right leg which developed one month earlier. Two weeks before admission he had had several seizures involving both arms and legs but without loss of consciousness.

On admission there was paresis of the left leg with increased knee and ankle jerks and diminished superficial abdominal reflexes on the left side. There was papilloedema. Several attacks of clonic jerking of all extremities were observed. Ears, nose and sinuses were negative. Pneumoencephalogram was negative.

The child remained afebrile. No chemotherapy was administered. Weakness of the left leg was present on discharge from hospital.

This child was considered to have had thrombosis of the superior longitudinal sinus with obstruction of the Rolandic veins of both hemispheres.

In the last report in 1951 there has been no recovery of the left leg and there have been frequent seizures.

CASE 15.—A twenty year old woman was admitted to the Montreal Neurological Institute in 1938 (Dr. Colin Russel and Dr. W. J. McNally). Four weeks earlier she had had persistent headache for five days. After an interval of three weeks the headache returned associated with chills. On admission she was disorientated. She had a stiff neck, and, Kernig's sign was present. Temperature was 102 degrees. She had paresis of the right hand. The spinal fluid pressure was 250 mm. There were no cells in the spinal fluid. The otolaryngological findings were normal. She had staphylococcal cystitis.

Five days after admission nystagmus was present on gaze to the left. Pneumoencephalogram was normal. In two weeks all abnormal neurological signs had disappeared. No follow up information has been available.

CEREBRAL VENOUS THROMBOSIS COMPLICATING PNEUMOCOCCAL MENINGITIS

(One Case)

CASE 16.—A female aged eleven months was admitted to the Montreal Neurological Institute in 1944 (Dr. A. R. Elvidge). One month before admission repeated vomiting had occurred followed after one week by several generalized seizures. Two weeks before admission she had a series of right sided seizures followed by transitory paralysis of the right arm and leg. The spinal fluid had contained 87 w.b.c.

On admission the child was in shock; she was dehydrated and comatose; the head was enlarged; the right pupil was dilated and fixed to light. There was ptosis of the right upper lid. There was left hemiplegia and paralysis of the right leg.

An exploratory craniotomy on the right side revealed brain softening with haemorrhage and necrosis in the right parietal lobe. Death followed and autopsy showed the longitudinal sinus to be thrombosed in its entire length. Numerous superior cerebral veins were thrombosed on both sides. Subarachnoid exudate was present over the convexity of the brain and in the Sylvian fissures. Cultures of the purulent material yielded pneumococci.

The necrotic and haemorrhagic material found at operation would seem to have been a haemorrhagic infarct resulting from venous occlusion.

In this connection Cairns and Russell[16] have pointed out the frequency of intracranial thrombosis, both venous and arterial, in association with pneumococcal meningitis.

REVIEW OF THE LITERATURE

In 1887 Money[62] called attention to the importance of cerebral vein thrombosis as a cause of fits in children. He reported the illness of an infant who had a series of unilateral convulsions alternating from left to right sides with corresponding left and right transient hemiplegia. At autopsy thrombosis of numerous cortical veins was found with spotted blood extravasation over the left hemisphere. No clotting was evident in the superior longitudinal sinus.

Gowers[32] in 1888, aware of the case reported by Money, suggested that cortical venous thrombosis might be one of the causes of infantile hemiplegia.

Hoffman[37] in 1897 reported on a patient who following left sided otitis media and mastoiditis developed papilloedema, paresthesias of the right hand, arm and shoulder and right facial weakness. Brain abscess being suspected, exploration was performed but no abscess was found. The mastoidectomy site was re-explored and the lateral sinus was found thrombosed. The patient recovered completely in two months. The author suggested that the focal signs were due to thrombosis in the cerebral veins and he indicated that obstruction of the lateral sinus also interfered with drainage of the cerebrospinal fluid, thus accounting for the increased intracranial pressure.

Other authors have reported certain neurological complications in the pregnant and puerperal states. The similarity of these complications to those under consideration will become apparent.

In 1902 Sinclair[83] contributed a paper dealing with certain intracerebral complications of pregnancy and the puerperium, specifically aphasia, hemiplegia and fits. He described a patient in the seventh month of her pregnancy who became suddenly aphasic with loss of sensibility in the right thumb and forefinger and at the angle of the mouth. Thrombosis of veins of the foot also occurred. She recovered and delivered normally at term.

He collected seventeen similar cases from the literature including three which had died. These showed at autopsy vascular lesions of the brain. Sinclair suggested that the altered condition of the blood in pergnancy and the puerperium was favourable to thrombosis. He did not emphasize venous thrombosis but spoke broadly of cerebral thrombosis, presumably arterial.

von Hösslin[94] in 1904 reviewed the literature of post-partum paralysis with special attention to the findings at autopsy. He collected twenty-four cases. He believed that excessive loss of blood at the time of delivery tended to favour thrombosis. He remarked that thrombosis of the cortical veins of the brain seemed frequently to be the cause of post-partum paralysis and probably also accounted for the convulsions which often preceded paralysis.

In 1929 Alpers and Palmer,[3] in a study of neurological complications of pregnancy and the puerperium, reviewed the literature from 1904 (since von Hösslin's contribution) and collected six cases of thrombosis of cerebral veins and sinuses of which five died. In these, extensive thrombosis of sinuses as well as veins was demonstrated at autopsy.

Since then reports by a number of investigators relating to post-partum cerebral complications have appeared from time to time.

Thomson[92] in 1940 reported transient right hemiplegia and blindness of the left eye, with obstruction of the central retinal artery, in a patient one week after miscarriage. Although the hemiplegia disappeared in two days visual diminution persisted. He suggested as a cause, thrombosis of the internal carotid artery.

In 1941 Martin and Sheehan[58] reported five patients with post-partum fits and hemiparesis, three of which were followed to autopsy. All of these showed thrombosis of superior cerebral veins. These investigators reported also on a patient who developed convulsions, astereognosis of the right hand and alexia during typhoid fever, but who recovered in six weeks. Cortical venous thrombosis was considered to be the cause.

Stansfield[84] in 1942 reported two cases of puerperal cerebral thrombophlebitis one of which died showing superior longitudinal sinus thrombosis and thrombosis of veins over the left frontal lobe. The other recovered under heparin therapy.

In the same year Joseph,[46] and, Cairns and Melton[17] reported two cases.

In 1944 Martin[56] recorded two additional post-partum cases of cerebral venous thrombosis and commented on the frequency with which the upper limb was involved when the lesion was unilateral.

Davidson[22] in 1945 reported a patient who, in the puerperium, developed thrombosis of the superior longitudinal sinus and superior cerebral veins.

McNairn[60] in 1948 gave an account of two patients with sudden hemiplegia and recovery during late pregnancy. One of these had focal seizures. The author assumed that these manifestations were the result of cerebral venous thrombosis; she suggested that the increased fibrin content of the blood (40% higher than normal at term) predisposed to this complication.

Symonds,[87] long interested in the problem of otological complications, contributed to it in several communications. In 1927, discussing the differential diagnosis of cerebral abscess, he reported on three patients with otitis media who presented complicating evidence of focal cerebral disorder which subsided. He considered this to be due to non-suppurative meningitis localized in the Sylvian fissure. He based this hypothesis on the resemblance of the clinical picture to that which he had observed previously in a patient who had a superficial cortical abscess. He concluded that, in the three patients who spontaneously recovered, local meningitis occurred which did not progress to suppuration.

Watkyn-Thomas[96] in a discussion of this paper described a case of frontal sinusitis complicated by aphasia and weakness of the right side of the tongue and lower face. At operation he found a loculated collection of subarachnoid, purulent spinal fluid near the lower motor cortex. The patient died but at autopsy no track of infection could be discovered. A cortical depression was present over the anterior portion of the left Sylvian fissure, the foot of the Rolandic area and the third frontal convolution. Although he did not describe the veins or sinuses, we suggest that this cerebral lesion may have been the result of cortical venous occlusion.

In 1931 Symonds[88] applied the term otitic hydrocephalus to the syndrome of increased intracranial pressure and normal spinal fluid occurring as a complication in otitis media. He classified under this diagnosis cases which Adson had described and had called pseudo-brain abscess. Symonds suggested that the increased intracranial pressure was due either to excessive secretion from the choroid plexus or defective absorption through the arachnoid villi.

McAlpine (1931)[59] suggested the term "toxic hydrocephalus" since he observed the complication not only in otitis media but also

in nasopharyngitis and other infections. He considered the hydrocephalus to be caused by over production of spinal fluid.

In 1937 Symonds[89] enlarged his own concept and stated his belief that otitic hydrocephalus was the result of villous obstruction by mural thrombophlebitis of the superior longitudinal sinus, the result of retrograde extension from the lateral sinus. He postulated, furthermore, that the occurrence of focal epilepsy and hemiplegia in this condition was due to thrombophlebitis of the tributary veins of the superior longitudinal sinus.

Meanwhile, Courville and Nielsen (1935)[21] reviewed the broad aspects of the problem as it appeared in the course of febrile illness in infancy and childhood. They recognized the combination of fever, convulsions and hemiplegia as a clinical syndrome. In their analysis of twenty-three cases, with this symptom complex, all were found to have otitis media. They emphasized the importance of middle ear disease as the cause of the febrile state. They suggested that the convulsions and palsies in these instances were the result of venous thrombosis over the cortex by rapid retrograde extension from the lateral sinus along the inferior anastomatic veins to the Rolandic area. They emphasized the middle ear as the disseminating site of the infection. These authors also were impressed with the type of palsy observed and stressed that, in seventeen of the twenty-three cases, the paralysis involved face and arm more than leg.

Symonds[90] in 1940 reported five patients in which he said "the diagnosis of cerebral thrombophlebitis was reasonably founded." In two instances there appeared to be direct spread from frontal sinusitis; both of these cases developed transient hemiparesis especially of the lower limb. In another case, following an upper respiratory infection, two episodes of hemiparesis involving chiefly face and arm occurred. Two other cases were puerperal with focal fits and brief hemiplegia. In one of these the lesion was confirmed at operation. This patient, in the second week after delivery, was taken with headache and transient paralysis of the left arm. Following this there was a series of seizures beginning in the left face and arm. Papilloedema and hemiparesis, particularly of face and arm, followed. At operation a thrombosed vein in the Rolandic fissure was seen as a white, opaque streak. The arteries were normal. The cortex itself was soft and gummy in this region but responded to electrical stimulation. Complete recovery ensued in one month. In 1926 Dowman[24] reported on a patient who for five days had had repeated

brief episodes of dizziness and a twitching sensation in the right eye. Six days later there was sensation of numbness in the left hand spreading to the left arm face and trunk and, to lesser degree to the left leg. Examination showed weakness of the right hand, astereognosis, two point sense loss, loss of passive movement and sense of position in the left arm and leg.

At operation an excessive amount of fluid in the subarachnoid sulci was observed. The Rolandic vein was hard and could be rolled under the finger. The cerebral convolutions were somewhat harder than normal. Complete recovery followed in one month. The cause of the thrombosis was never determined.

Waggoner[95] in 1928 reported a patient who suddenly developed paralysis of the right leg and to some degree the right arm. There was astereognosis in the right hand but no aphasia. Death of intercurrent bronchopneumonia occurred.

At autopsy thrombosis of the left Rolandic vein was demonstrated without extension into the superior longitudinal sinus. Beneath the thrombosis was a plexiform hemangioma.

Davis[23] in 1933 reported a patient who developed weakness of the right hand after an upper respiratory infection. Six days before admission he had a series of left-sided seizures. He was found to have loss of cortical sensibility in the right hand.

At operation, on the left side, thin greenish exudate was found about the veins of the Rolandic area; the arteries were intensely red; the cortex was grey instead of the usual pink. The Rolandic vein was hard and when punctured was seen to be thrombosed. The patient was recovering from paralysis when he died of intercurrent bronchopneumonia, on the fourth day after operation. Autopsy revealed thrombosis of the Rolandic and several adjacent smaller veins. No thrombosis of the superior longitudinal sinus was seen. There were numerous small haemorrhages immediately under the Rolandic vein giving the appearance of a single large haemorrhage.

These findings are not unlike those described by Watkyn-Thomas (Cf. supra).

Guillaume[33] in 1943 reported on a patient who suddenly had a series of right-sided seizures and became stuporous, hemiplegic and aphasic. Ventriculogram showed shift of the midline structures to the right and smallness of all parts of the left lateral ventricle.

At operation the brain was tremendously swollen and congested. The Rolandic vein was greatly distended and firmly thrombosed. The vein was resected and thrombosis was verified histologically.

The patient recovered.

Other contributions have appeared to the present writing, Cobb and Hubbard[20] in 1929 described the morbid anatomy of venous occlusion. Case reports with autopsy confirmation have been frequent, together with reports in which the clinical evidence is indicative of cerebral thrombophlebitis or phlebothrombosis.

The entire subject has been splendidly reviewed in a recent publication by Garcin and Pestel.[31]

THEORIES OF DISSEMINATION; THE VASCULAR PATHWAYS

The frequency with which the venous dural sinuses become thrombosed in infections about the head does not need emphasis. It is easily conceivable, therefore, that thrombosis or thrombophlebitis of the tributaries may occur.

If it is assumed that, in the cases under discussion, thrombosis of the venous tributaries is the cause of the manifest cerebral symptoms, the pathways of spread from the disseminating sites may be considered.

Courville and Nielsen[21] offered an hypothesis for dissemination from the middle ear to the veins of the parietal and frontal lobes. They considered that thrombosis of the lateral sinus first occurred with secondary spread by the inferior anastomotic veins to those of the Sylvian fissure which drain the lower convexity of the cerebral hemisphere.

We have seen the evidence for this at operation in two cases of cerebral abscess.

Hesse and others (1930)[35] found thrombosis of the inferior anastomotic veins and indicated that this might be the pathway for abscess formation in the temporal lobe. Hesse, himself, believed that thrombophlebitis was a precursor of cerebral abscess from a contiguous site such as the middle ear.

Irish (1938)[41] who studied necropsy material of 1000 cases of cerebrovascular lesions reported thirty-eight cases of lateral sinus thrombosis. Two showed thrombosis of anastomotic tributaries.

We have examined, at autopsy, fourteen cases of lateral sinus thrombosis. Four of these showed associated cortical venous thrombosis of the superior cerebral veins. In one instance there was thrombosis also of the inferior anastomotic veins.

Courville and Nielsen[21] also postulated that thrombosis of the superficial cerebral veins might occur at a distance from the primary site, such as the lateral sinus, with a break in continuity of the thrombotic process along the anastomotic pathways.

They suggested, finally, that superficial cerebral vein thrombosis might occur as an isolated phenomenon in the absence of sinus thrombosis. Gowers also was of this opinion. This is an attractive and reasonable theory and there is the following evidence to support it: The cases reported by Money, Dowman, Waggoner, Davis and by Guillaume; possibly too, the case reported both by Symonds, and, by Martin and Sheehan. (Cf. supra) Merwarth also reported a case proved at autopsy and Irish[44] reported seven others in his analysis of autopsy material.

Most frequently thrombosis of superficial cerebral veins as seen at autopsy appears to be associated with superior longitudinal sinus thrombosis. This was found in the three cases which we have followed to autopsy (Cases 10, 11, 16) and there is good evidence for this diagnosis in two others of our series (Cases 7 and 14).

Irish,[42] in addition to the cases mentioned above found thrombosis of the superior cerebral veins in seven of sixteen cases of superior longitudinal sinus thrombosis. The frequency of this association has been emphasized by others.

Isolated reports have been numerous.

SIGNIFICANCE OF LOCALIZING SIGNS

Holmes and Sargent[39] in 1915 reported on forty cases of gun shot injury of the superior longitudinal sinus. In all of these the lower limbs were predominantly affected. These authors indicated that the paralysis was due to obstruction both of sinus and superior cerebral veins. They pointed out that paralysis was invariably spastic and that sensory changes were of the cortical type.

Merwarth (1940)[61] collected a series of hemiplegias associated with parasaggital tumors. He emphasized the points made by Holmes and Sargent that the lesions produced a clinical syndrome char-

acterized by spasticity and paralysis of the distal portions of the lower extremity and proximal portions of the upper extremity usually sparing the face. He indicated that venous obstruction was responsible for the paralytic lesion.

Semmes (1927)[80] also had emphasized that thrombosis of the superior longitudinal sinus complicating frontal sinusitis could be recognized by paralysis of the legs extending at times, to the shoulder and arms but never affecting hands or face.

Explanation for the distribution of a characteristic paralysis is to be found in the representation of the body and limbs in the sensory-motor cortex.

Penfield and Boldrey (1939)[69] and Penfield and Rasmussen (1950)[71] have shown in man that somatic representation of foot and leg is found on the medial aspect of the cerebral hemisphere within the longitudinal fissure. A relatively small area at the superior convexity is the representation for shoulder, elbow and wrist; over the lateral convexity is a large area serving hand and fingers, below it to the Sylvian fissure is a large area for face. Adjacent to this, in the dominant hemisphere is a center for speech (Figs. 1 and 2).

A lesion of the precentral gyrus within the longitudinal fissure and including the superior convexity of the cerebral hemisphere will obviously produce paralysis chiefly of foot and leg, shoulder and arm.

On the other hand, a lesion of the lateral convexity, will produce paralysis of face, hand, fingers and arm.

We emphasize this point because of the frequent occurrence, in our own material and in reports by others, of palsies involving chiefly the upper limb, face and speech, and, least the leg.

We interject here a brief review of the venous drainage of the cerebral cortex.

Above the Sylvian fissure, the venous drainage of the cortex empties into the superior longitudinal sinus by a series of fairly constant and large venous tributaries. These may be grouped as frontal, precentral, central and post central. They lie in the sulci which separate the corresponding parts of the opercula of the Sylvian fissure.[66] The entire operculum itself is drained by the Sylvian vein.

The vein of the Sylvian fissure (superficial mid cerebral vein) drains into the cavernous sinus and ultimately into the lateral sinus.

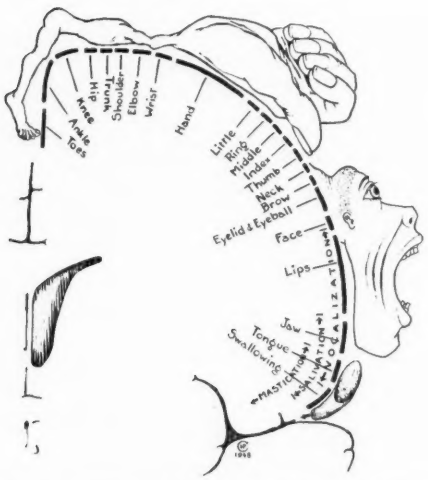

Fig. 1.—Shows somato-motor representation in the precentral gyrus. Note the relative positions of leg and foot, and, hand and face. From: Wilder Penfield and Theodore Rasmussen: The Cerebral Cortex of Man. Courtesy of the authors and MacMillan and Co., Publishers, New York, N. Y.

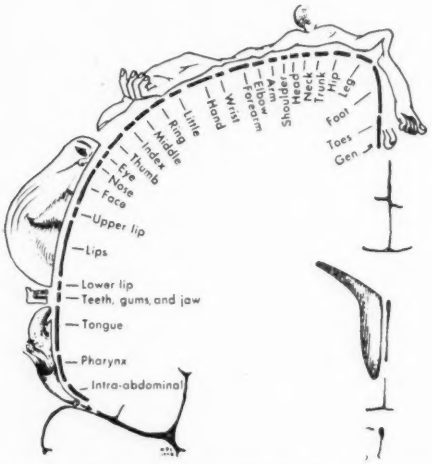

Fig. 2.—Shows somato-sensory representation in the postcentral gyrus. Note, again, the representation of leg and foot on the mesial aspect, and, of hand and face on the lateral aspect of the hemisphere. From: Wilder Penfield and Theodore Rasmussen: The Cerebral Cortex of Man. Courtesy of the authors and MacMillan and Co., Publishers, New York, N. Y.

The circulation of the temporal operculum of the Sylvian fissure is drained into the Sylvian vein. The latero-inferior parts of the temporal lobe are drained by a system of veins emptying into the lateral sinus which system also anastomoses with the Sylvian vein. In this way, a continuous network of veins provides anastomosis between the superior longitudinal and lateral sinuses.[86] The largest trunk connecting the Sylvian vein and the superior longitudinal sinus is frequently called the superior anastomotic vein of Trolard. This frequently corresponds to the central or Rolandic vein.

The largest venous trunk connecting the Sylvian vein with the lateral sinus is often referred to as the inferior anastomotic vein of Labbé.

This interconnection between the lateral and superior longitudinal sinuses has frequently been pictured as a single vein passing between the superior longitudinal sinus interrupting briefly at the Sylvian vein and continuing to the lateral sinus. This is not the usual anatomical arrangement as Lima[51] has emphasized in a study of phlebograms made in living human subjects.

The veins draining the mesial aspect of the cerebral hemisphere above the calloso-marginal fissure, empty into the superior longitudinal sinus in trunks corresponding with those of the supero-lateral convexity. These may come together and be enveloped in a common sheath but they rarely unite as a single tributary. Most often these pass together into the wall of the sinus and may pursue an intramural course for some distance[13, 85] before opening separately into the lumen beneath the lateral lacunae[18] (Figs. 3 and 4).

The veins have no valves, so that reversal of flow may easily take place. As a result of this there is probably no critical equator which determines that all venous flow above the entire operculum must invariably empty into the superior longitudinal sinus while that below must empty into the Sylvian vein.

We suggest, however, that in certain conditions which predispose to thrombosis of veins, this area, in the neighbourhood of the operculum is rendered particularly vulnerable by reason of the division in the venous outflow. We suggest moreover that thrombosis may occur here without thrombosis of a major dural sinus.

Should this take place in the region of the Rolandic gyri the resultant palsy would be most evident in the upper bodily segments

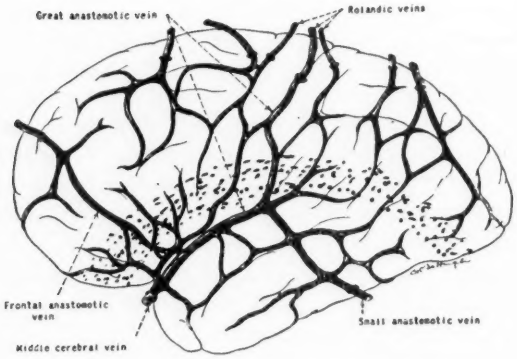

Fig. 3.—Lateral aspect of cerebral hemisphere showing venous network and major cortical venous channels. Stippled area represents the area of anastomosis between veins draining into the superior longitudinal sinus and those draining into the Sylvian vein to the cavernous and lateral sinuses. The Great Anastomotic Vein of Trolard is seen on the figure as Great Anastomotic Vein. The Inferior Anastomotic Vein of L'Abee corresponds to the Small Anastomotic Vein in the Figure. After Percival Bailey: Intracranial Tumors. Courtesy of the author and Charles C. Thomas, Publisher, Springfield, Illinois.

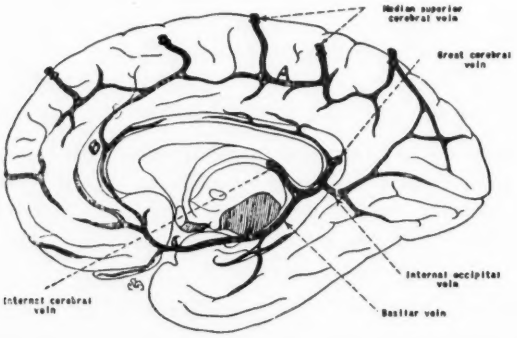

Fig. 4.—Shows venous drainage of mesial aspect of cerebral hemisphere. Note that veins above the cingulate fissure, indicated on the figure at *A*, drain superiorly into the superior longitudinal sinus. Anastomoses are also made with the anterior cerebral vein, indicated on the figure at *B*, and the great cerebral vein (vein of Galen). After Percival Bailey: Intracranial Tumors. Courtesy of the author and Charles C. Thomas, Publisher, Springfield, Illinois.

due to disturbances of circulation sufficient to interfere with functions of the area in which these parts are represented. This would explain the frequent association of focal seizures and palsies involving face or hand or arm. Should the thrombosis extend superiorly, leg would become involved. This exact sequence occurred in the case reported by Dowman and the lesion was demonstrated.

We have suggested that this area is vulnerable to thrombosis by reason of the division in its drainage where movement of the venous current occurs in a to and fro manner, and, is therefore slow.

We propose that, with complete obstruction to flow in one direction, reversal of the drainage outflow in the opposite direction is established. In this way obstruction is not permanent and, as a result, function of the involved area tends to recover quickly.

Another possibility which must be considered, especially in dissemination from the frontal and ethmoidal sinuses, is the obvious pathway of the superior longitudinal sinus. A mural thrombosis in the superior longitudinal sinus at the mouth of one of the prefrontal tributaries may lead to retrograde thrombosis of the tributary vessel. Resultant oedema of the frontal lobe may well give rise to facial weakness, and, in the dominant hemisphere, to aphasia, other signs being lacking.

This same pathway, the superior longitudinal sinus, may be involved by a spread from the lateral sinus in otitis media and mastoiditis. Thrombosis of the superior longitudinal sinus by extension from the lateral sinus is not unusual.[65, 20, 12, 64] Should this occur the resultant palsy might be alternating hemiplegia or quadriplegia depending on the tributaries occluded in the process.

But thrombosis of the superior longitudinal sinus and tributary Rolandic veins is not always accompanied by hemiplegia predominantly of the lower limb. The paralysis may be complete on one side and strongly suggest a capsular hemiplegia, or indeed, it may appear chiefly as a brachio-facial weakness.

The explanation for this latter type of palsy in the presence of thrombosis of superior veins and superior longitudinal sinus may lie in the escape of the separate venous tributaries serving the mesial aspect of the hemisphere.

It may be argued that the thrombosis first appears in the veins and extends to the sinus. There is evidence of this in the fact that

Fig. 5, Case 11.—Shows thrombosis of the superior longitudinal sinus and numerous tributaries. Note the spotted character of the hemorrhagic extravasations which become confluent in large areas.

in some instances, the hemorrhagic softening in the region of the thrombosed veins seems to be older than the clot obstructing the sinus.

On the other hand there are instances where the opposite is true.[36]

From the pathological stand point both possibilities would seem to be valid.

PATHOLOGY

The characteristic lesion produced by venous obstruction in the brain is hemorrhagic softening and necrosis.

This occurs as numerous small hemorrhages which tend to become confluent and are conspicuous in the grey matter immediately underlying and adjacent to the thrombosed vessels. There may be and frequently is subarachnoid haemorrhage of variable degree (Figs. 5 and 6).

Fig. 6, Case 11.—Lateral view of specimen shown in Fig. 5. Note again the numerous cortical hemorrhages. The thrombosed veins are evident.

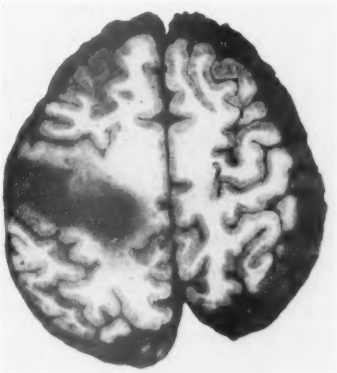

Fig. 7, Case 11.—Horizontal section of same specimen. Note the confluence of hemorrhage in the centrum semiovale. Note also the many discrete hemorrhages in the cortical grey matter.

Although the cortical changes are striking, it is also true that haemorrhagic necrosis extends into the white matter to a certain degree, and, in some instances this may be widespread.

In this connection, as was pointed out by Cobb[19] and emphasized by Shenkin, Harmel and Kety,[81] the cortical veins drain deeply in the substance of the brain where they establish communication with the internal or Galenical venous system.

This type of infarct is in contrast with the anaemic necrosis[68] of sudden and persistent arterial occlusion. In the latter situation haemorrhage does occur at the periphery of the affected arterial territory and is found within the grey matter. It does not however, appear in white matter at least in man and in monkey.[28]*

The red infarct in the centrum semiovale is obvious in the accompanying photographs (Fig. 7).

Similar findings were reported by Hirsch[36] in which symmetric haemorrhagic necrosis in the centrum semiovale was discovered in both cerebral hemispheres. Many others have confirmed haemorrhagic necrosis as the typical lesion of venous thrombosis.

The morbid anatomy of venous obstruction in the Galenical system is essentially the same but with characteristic distribution in the basal ganglia.[26] It has not been possible as far as we know, to reproduce these findings experimentally either in dog or monkey.[8]

In acute experiments, Schlesinger[79] showed that the earliest effects of venous obstruction were proximal distention of the venous tree and perivascular extravasations.

These extravasations are followed by confluence of haemorrhage, necrosis of the involved area and demyelinization of white matter.[2, 78]

The process is accompanied, microscopically, by mobilization of microglia, swelling of oligodendroglia, astrocyte metamorphosis and destruction of nerve cells.[12]

In the chronic state this results in shrinkage of the involved area with replacement gliosis and discoloration with haemosiderin pigment.

If the lesion is large enough it is not inconceivable that a cyst may occur. Marburg and Casamajor,[54] and, Marburg, Resek and

*There is evidence, however, that haemorrhagic central necrosis may take place in arterial occlusion of other species as in the dog.[34]

Marks[55] have considered that Galenical vein obstruction is the primary cause of porencephaly though they do not reject the possibility of coincident arterial obstruction.

In as much as red infarction is the typical lesion of venous occlusion, we have considered cerebral venous thrombosis to have been the cause of the findings described in Case 12.

CORTICAL VENOUS THROMBOSIS AND EPILEPSY

Bailey and Hass[7] pointed out the similarity of the cicatrix resulting from venous occlusion to that described by Foerster and Penfield which has been considered to be epileptogenic.[29]

It will be recalled that in five of the cases which we have reported, habitual epilepsy has followed (Cases 3, 5, 6, 12, 14).

We submit that cerebral venous thrombosis, occurring either in the febrile states of infancy and childhood or as a complication of infections especially of the ears, nose and throat during any decade, may be a cause for epilepsy, especially of focal type.

An analysis of 84 cases of focal epilepsy studied at the Montreal Neurological Institute revealed that febrile infectious or toxic states were considered the events from which the seizures devloped in 5 cases.

We report one example of this group.

A 6 year old female was admitted to the Montreal Neurological Institute (Dr. Wilder Penfield) for treatment of seizures. Her birth and neonatal period were uneventful and she had developed normally until the age of 14 months. At that time she was taken with fever and a rash. Shortly afterward she had a series of left sided seizures and became hemiplegic for 24 hours. Fever rose to 106° whereupon right sided seizures appeared and she fell into epileptic status for 10 hours. She slowly recovered but, with subsidence of seizures, it was evident that she was hemiplegic on the right side, the paralysis on the left having disappeared. She reverted to an infantile level.

About a year later she began to have recurrent seizures of two types, some being characterized by jerking of the right arm and face, others by staring and sudden cessation of activity.

On examination she showed underdevelopment of the right limbs,[72] right hemiparesis, obvious speech difficulty, irritability and unpredictable behavior.

At operation, no evidence of occlusion of arteries or veins was seen but cortical atrophy was widespread.

We raise the question of cortical venous thrombosis as the cause of the cerebral damage in the responsible febrile episode and suggest that recanalization of the veins may have occurred in the interim as in the cases reported by Bailey and Hass.[7]

INTRACRANIAL VENOUS THROMBOSIS AND BRAIN ABSCESS

A number of authors have considered cerebral cortical thrombophlebitis to be the precursor of brain abscess.

We have reviewed 125 cases of brain abscess; thirty-nine came to autopsy. Cortical thrombophlebitis was present in only four cases of the entire series.

Irish,[41] in his extensive study of Intracranial venous and sinus thrombosis found six abscesses; five in the cerebellum and one in the temporal lobe. Two of the cases of cerebellar abscess showed associated cerebellar vein thrombosis. On the other hand, cerebellar veins were found thrombosed in four cases without abscess formation and all cases were of infectious origin. In the single case of temporal lobe abscess, no thrombosis of cerebral veins was evident.

Moreover, in seven instances of isolated cortical venous thrombosis which he reported, Irish found two cases of abscess, both of these being in the cerebellum as noted.

It would appear therefore, that although thrombosis of cortical veins may occur and play an important part in the pathogenesis of abscess in the brain, it is not often grossly demonstrated.

Whether the pathway from the locus of dissemination is intravascular[21] or perivascular[5, 6] does not concern us in this discussion. It should be pointed out that vascular thrombosis, arteriolar and venular, is commonly found at the site of abscess formation.[2] We do not propose to comment in this report, on whether this is a primary or secondary phenomenon.

DISCUSSION

The complication which this syndrome presents in the course of suppuration about the head is not common. We must emphasize that we found in our own material, 12 cases in which the primary focus was in the nasal sinuses and middle ear.

During the twenty-five year period, covered by the study, more than 350 cases of acute sinusitis and more than 4,750 cases of acute otitis media were treated in hospital (exclusive of out-patients). i.e. cerebral venous thrombosis occurred in about .2% of these cases.

In the same period we collected 82 cases of brain abscess of sinus and otic origin, roughly a percentage of 1.5%

This lends emphasis to the point that whenever signs of cerebral involvement are manifest, brain abscess must be the first consideration in differential diagnosis.

Nevertheless, it should be born in mind that, in the present day of chemotherapy, the process of suppuration may be arrested at an intermediate stage. Our experience would indicate that this occurs and that cerebral venous thrombosis may more frequently be encountered.

DIFFERENTIAL DIAGNOSIS

In the course of infections of the nasal sinuses and middle ear, supervening signs of cerebral involvement are usually indicative of intracranial abscess, meningitis, thrombosis of dural venous channels or a combination of these.

The occurrence of stupor, seizures, focal pareses and increased intracranial pressure is especially indicative of intracranial abscess either epidural or subdural or suppurative encephalitis itself (brain abscess). None of these complications can be distinguished on a clinical level from each other or from the syndrome of cerebral venous thrombosis without appropriate investigation.

Uncomplicated meningitis, except in infants and children, is rarely accompanied by seizures. In an analysis of 125 autopsy records of meningitis, excluding those of tuberculous origin, 10 patients had convulsions, 8 of these were children of 5 years or younger. Only two were adults and one of these showed thrombosis of the superior longitudinal sinus and tributaries.

Moreover, uncomplicated meningitis does not give rise to focal signs. If focal signs are present in meningitis, one must suspect further complication.

Thrombosis of the major venous channels, such as the lateral or superior longitudinal sinus, may be suspected on the grounds of febrile rise, headache, lethargy, and increased intracranial pressure.[52]*

The differential diagnosis in all of these complications, depends ultimately on the exclusion of intracranial suppuration. For further general discussion of differential diagnosis the reader is referred to the recent contributions of Symonds,[91] and of Purdon Martin.[57]

TREATMENT

Long before the advent of chemotherapy and antibiotics, the necessity for adequate surgical drainage of a focus of infection was well known.

It is our opinion that this is still the first step in treatment. Bearing in mind that cerebral venous thrombosis is, for the most part, a complication of disease in the sinuses, middle ear and mastoid, the first attack should be directed against the primary disease. We emphasize that a number of the earlier cases recovered with drainage of the disseminating site alone.

Adequate chemotherapy should be administered but should not be depended upon to the exclusion of appropriate surgical measures.

SUMMARY

1. Sixteen cases of focal cerebral disorder simulating brain abscess are presented as examples of a syndrome ascribed to cerebral venous thrombosis.

2. The frequent occurrence of brachiofacial seizures and palsies is emphasized.

3. These are discussed in the light of cerebral localization and the anatomy of venous drainage of the brain.

4. Appropriate literature is reviewed.

5. The importance of cerebral venous thrombosis as a cause of epilepsy and persistent neurological defects is emphasized.

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*We have found in a series of over 50 cases of lateral sinus thrombosis, proved by sinusotomy, that 9 developed persistently elevated intracranial pressure. One patient was rendered blind.

6. The relationship of intracranial venous thrombosis to brain abscess is discussed.

7. A statistical analysis of the occurrence of this syndrome in suppuration about the head is briefly included.

8. It is suggested that the syndrome may be more frequently encountered as a result of modern chemotherapy.

9. The importance of eradication of the disseminating focus is emphasized.

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XLI

AIR CURRENTS IN THE UPPER RESPIRATORY TRACT AND THEIR CLINICAL IMPORTANCE

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PART I. NORMAL CURRENTS

Not long ago any detailed study of the patterns of respiratory air currents would have been regarded as an academic pursuit—a hobby, perhaps, for some retired physiologist. That the subject is completely omitted from most contemporary textbooks indicates that their authors, if indeed they are familiar with it, still regard it in that light.

Nothing could be farther from the fact.

Respiratory patterns are closely related to clinical manifestations such as the common cold, which play an important part in the public health and economy.

Before launching upon a description of the experiments and a discussion of nasal air currents it will be useful to outline briefly the behavior of air currents carrying particulate matter through closed channels.

So long as air passes at an unvarying speed through a smooth straight tube of constant calibre no turbulence occurs and light particles which it may contain remain air-borne.

If the tube is bent, however, so that the air current changes direction, some turbulence occurs and air-borne particles are deposited on the walls, not at, but immediately *beyond*, the bend. The more abrupt the bend, the greater the turbulence and the greater the deposit of particulate matter. This phenomenon has been termed the "impingement effect."

A similar deposit occurs if, instead of being bent, the tube is constricted. In this case, also, the deposit accumulates *distal* to the constriction (Fig. 1).

That such a phenomenon must have a profound effect when applied to the nasal chambers and the germ-laden air which passes

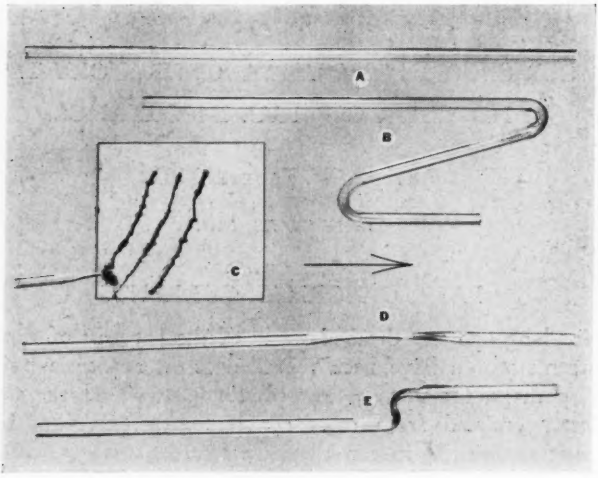

Fig. 1.—The Impingement Effect. Deposits are left by smoke passing through glass tubes: negligible deposit in a straight tube of constant diameter, *A*. A change in the direction of flow produces turbulence, impingement and deposit *distal* to it, *B*. Constriction has a similar effect, *C*. *D*. Constriction and kinking together cause maximum deposit, *E*.

through them is obvious, especially when the local drying effect is included.

Moisture-laden air deposits droplets of water at the impingement points mentioned (temperatures being suitable) and conversely dry air passing through wet tubes will produce drying at these points.

Ciliary activity requires above all a moist medium. Drying is fatal to it and to the ciliated epithelial layer itself. If a situation exists, or is created, in the nose in which local drying occurs, then the protective mucous blanket at that point becomes thick and sticky, the cilia no longer propel it and conditions are favorable for bacterial growth and penetration. In smokers such spots can sometimes be demonstrated by the local deposits of tobacco tar.

The purpose ot the following investigation is to demonstrate the pathways of the upper respiratory currents and to study the effects of the impingement phenomena in normal and obstructed air passages from the anterior nares to the glottic chink, that is to say the whole upper respiratory tract. As will be shown, the mouth plays an important part in warming and moistening the air, and is accordingly included in the study. One has but to take a deep breath

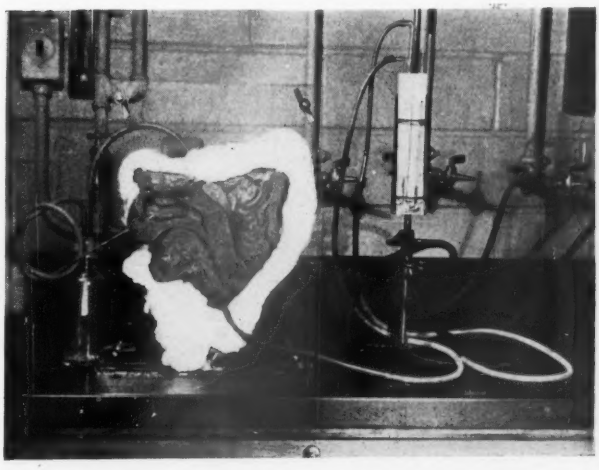

Fig. 2.—The Experiment with the Cadaver. On the left a smoke apparatus is applied to the naris of an anatomical specimen between glass plates. On the right, positive and negative pressure lines, with manometers, connect with the trachea.

with the lips closed to be aware of the air currents which are projected sharply against the base of the tongue and eddy in the back of the mouth.

EXPERIMENTS

Cadaver. The first experiments were made with anatomical specimens following, in the main, the method described by Franke in 1893. A head was cut in half, the saw falling exactly in the line of the septum. A second cut was then made approximately one inch to the side and in a plane parallel to the first.

This section of tissue, exposing on one side the nasal cavity and on the other the cavity of the maxillary sinus, was clamped between two plates of glass. The periphery was packed with wet cotton in such a way as to render the preparation air tight except for the nostril and the opening of the trachea where it was cut across an inch or so below the larynx[6] (Fig. 2).

Air Pump and Smoke Apparatus. In order to delineate the pathways taken by the air in the various preparations and models, smoke was introduced into the system while the air was flowing. In this way currents could be studied and photographed, and the conditions of the experiment repeated or continued as long as required.

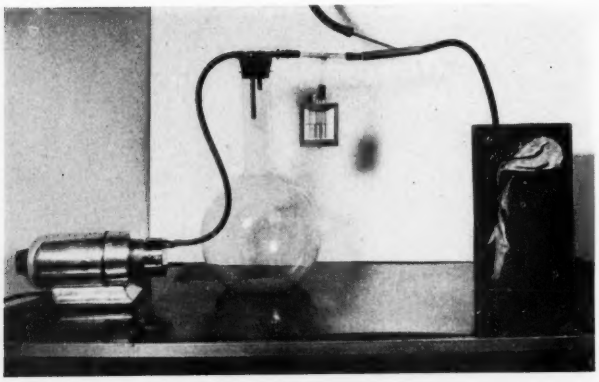

Fig. 3.—The Experiment with a Cast. Air from a pump, left, passes through a flask, to damp pulsations, and a manometer, to the model of the respiratory tract. Smoke is introduced from above.

First it was necessary to supply air at controlled pressures (and hence volumes) to simulate normal breathing, forced breathing, sniffing, talking and so on as desired. This was done by means of a small rotary electric pump having a sensitive control rheostat. To smoothe out the slight pressure pulsations inherent in the pump a large (2-litre) flask was introduced as a buffer between the pump and the model (Fig. 3).

Next to the specimen or the model a water manometer was coupled to measure positive and negative pressures in the trachea or the nose, as required.

In order to duplicate natural conditions precisely both positive and negative (expiratory and inspiratory) pressures should originate at the tracheal end of the passage, and the earlier experiments were done in this way. It became apparent, however, that it made no difference in the characteristics of the currents and eddies whether the pressures were applied at one end or the other so long as the proper differential existed, and since drawing the smoke through the pump soon resulted in fouling this piece of apparatus only positive pressures were used in the later experiments applying them to trachea or nostril as required. This was done only after numerous careful comparisons indicated that the results were not being vitiated.

Whenever small quantities of smoke sufficed cigarette smoke was introduced into the system from the investigator's mouth. When larger amounts were required for a longer time a one-inch brass tube

Fig. 4.—The Cast, a faithful reproduction of the tract is covered with a sheet of plastic "glass." Before it lies the pliable rubber mold from which it was made.

fitted to a solid base was filled with pipe tobacco and air was pumped through it. Other chemical "smokes," such as titanium tetrachloride, were discarded because of their corrosive action on the apparatus.

Cast Models and Rubber Matrix. Since a large number of observations were contemplated and the anatomical specimen, unwieldy to begin with, had to be taken from between its glass plates and returned to its pickling solution after each session, casts were resorted to.

A master cast was first made in plaster paris, and from this a model was cast in Duroc, a hard cementlike substance used by dentists.

From this in turn a rubber latex cast (Fig. 4) was poured, which was pliable and at the same time accurate in the finest detail, and which could be disengaged from the undercuts without having to resort to a sectional mold. From this rubber matrix a number of models were cast in Duroc and adapted to various purposes, as follows:

Sagittal Model for Lateral View. The first model reproduced the section from the head between the glass plates, and was used for watching currents passing in sagittal planes. The cavity in the

Fig. 5.—Inspiratory Pattern in the Normal Nose and Throat. Smoke laden air passing from the naris to the trachea, at the normal inspiratory rate.

stone block duplicated one-half the nasal cavity (the left) and the septum was replaced by a sheet of acrylic plastic. Proper openings were left in the block to carry air to the nostril and the trachea, care being taken to preserve the contours of the naris at its opening.

Mindful of the fact that the flat surface of the plastic sheet did not truly represent the contours of the septum, the various ridges and thickenings, within normal limits, were reproduced by applying moulded rubber pads of appropriate sizes and shapes in the proper places which, however, failed to alter the courses of the air currents in any respect. Changes brought about by abnormal thickenings and obstructions will be discussed subsequently.

Fig. 6.—Diagram of the Preceding. Note the sharp change of direction in the nasopharynx and the eddies in the oropharynx and the hypopharynx.

Curves obtained with the cadaver and with this model are illustrated in Figs. 5 to 8. The model itself, with its "plexiglas" cover is shown in Fig. 4.

Transverse Model. This casting was made to accommodate a transparent plate in the sagittal plane as before, and another in the plane of the posterior pharyngeal wall through which the lateral characteristics of the pharyngeal currents can be observed as they traverse the pharynx. The sagittal transparent plate was retained for illumination. The transverse model is shown in Fig. 9; curves obtained with it, in Figs. 10 to 13.

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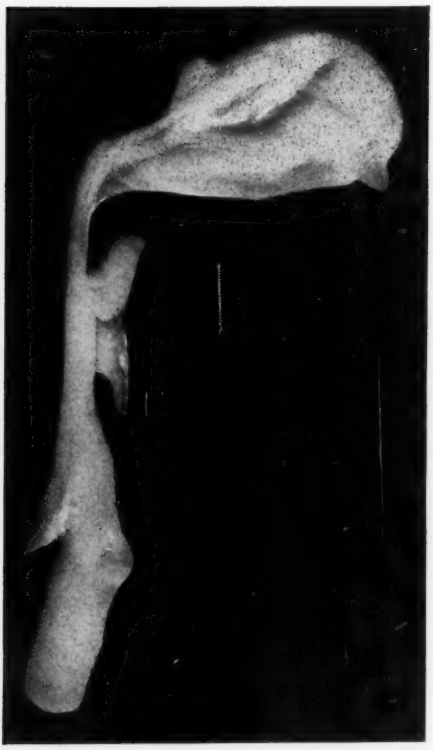

Fig. 7.—Expiratory Pattern in the Normal Nose and Throat. Smoke laden air passing from the trachea through the naris at the normal expiratory rate.

Impingement Model. This model is similar to the others except that it is designed to lie flat, and has hose connections to permit large quantities of smoke or particulate matter to be transmitted through it for long periods. The cavity is colored white when smoke or dark particulate matter is used, and black when white impalpable powders are used. Its purpose is to show the areas of the nose and throat against which inspiratory air currents impinge and deposit suspended matter such as dusts and pathogenic agents. Areas in which these deposits occurred are shown in Fig. 18.

Thermometric Measurements. Thermometric measurements were made in living subjects by means of a small thermocouple completely encased except for the tip in a vinylite tube. The open end

Fig. 8.—Diagram of the Preceding. Note the turbulence in the oropharynx and the double eddy in the nasal chamber.

of the tube extended 2 mm beyond the tip of the instrument, and two circular windows were made in opposite walls of the tube at the level of the metallic junction (Fig. 14). This effectively insulated the shank of the instrument and prevented any part of it from coming in contact with the wet walls of the nose, tongue and throat, while permitting a free flow of air to the critical point.

With this instrument it was intended merely to demonstrate a temperature differential between inspired air at the choana and at the hypopharynx; no precautions were taken to insure absolute measurements at either point. The important element was to determine as nearly as possible what portion of the heating function

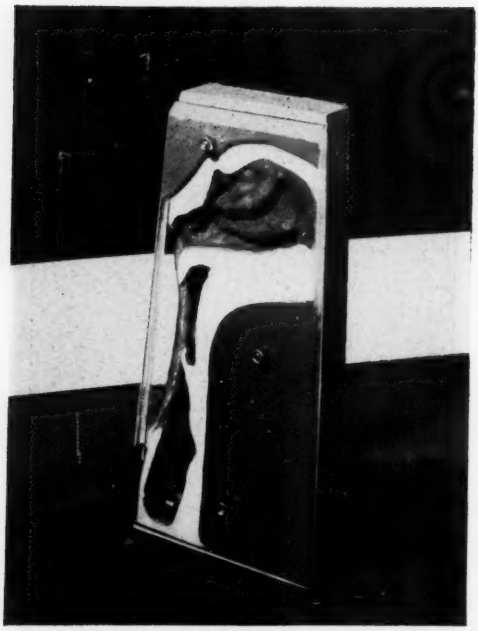

Fig. 9.—Model with an accessory glazed window in the posterior pharyngeal wall to permit observation of the currents from that direction.

of the upper respiratory tract is contributed by the nose and what portion by the pharynx and tongue. Some twenty readings were made under different room temperatures.

ANATOMICAL CHARACTERISTICS

Investigators generally accept the inspiratory air streams in the nose as they were first described in detail by Paulsen[4] in 1882 (Fig. 15). Regarding the pathways of expiratory currents there is less agreement. The diversity of opinion here suggests that different nasal conformations produce different currents and this is to some extent true, but careful experiments in which nasal proportions were altered at will lead to the conclusion that there is a basic pattern which closely resembles that originally suggested by the present author in 1932 (Fig. 8).

The Nose. The anterior naris is nearly horizontal and the axis of its lumen therefore approaches the vertical. However, owing to the conformation of the columella and, laterally, the *limen vestibuli*

Fig. 10.—Inspiratory pattern seen from the rear.

Fig. 11.—Diagram of the Preceding. Note the main current, narrowing, in a direct path from choana to glottis. Collateral currents fold about the velum palati and the epiglottis.

the entering currents are directed for 1 cm obliquely toward the septum before turning directly cephalad. This point 1 cm within the anterior naris is the narrowest portion of the upper respiratory tract and plays an important role in the determination of air currents and pressures.

Under normal breathing conditions the airways of the nasal chamber are all narrow slits rather than tubes, as can be readily seen in tomographic roentgenograms, and the air streams and eddies are molded accordingly.

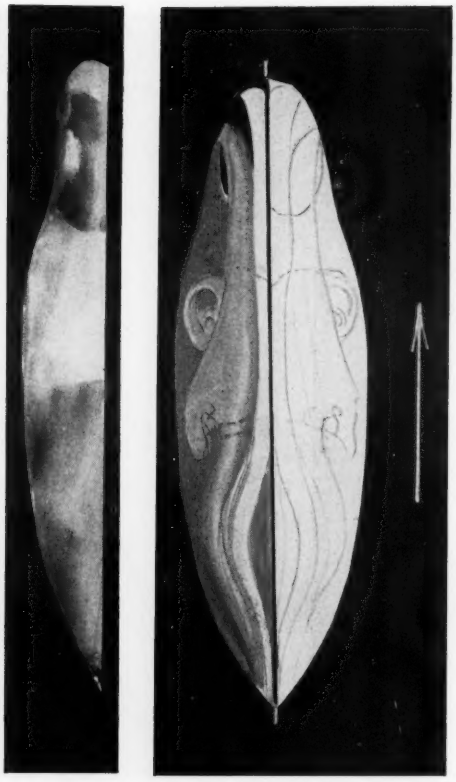

Fig. 12.—Expiratory Pattern, seen from the rear.

Fig. 13.—Diagram of the Preceding. The main current is somewhat more devious, the collateral eddies less well defined.

The turbinated bodies have very little to do with the direction of inspiratory currents, lying largely lateral to them and being streamlined to them. Expiratory currents, on the other hand, enter the meatuses from behind and are divided by the overhanging turbinates.

The Pharynx. In the nasopharynx, a flattened funnel shaped space, air currents encounter a constriction and at the same time undergo a sharp change in direction.

During normal breathing the tongue and the soft palate do not lie wholly in apposition. In most individuals only the tip of the

tongue is in contact with the hard palate and the upper incisors; in some there is contact over most of the hard palate. In any case a part of the mouth remains as a chamber accessory to the breathing tract, and assists in warming and moistening the air. As previously noted this can be demonstrated by nasal breathing of cold air which can be felt impinging and eddying upon the back of the tongue. At the end of the inspiration a cold spot remains there which is rewarmed by the ensuing expiratory blast and the circulation at that point.

During speech, swallowing or any other voluntary motion of the pharynx and tongue the epiglottis assumes a number of positions with relation to the surrounding structures,[3] but observation through a nasopharyngoscope during quiet respiration shows it occupying positions roughly midway between the tongue and the pharyngeal wall where it presents a baffle to inspiratory currents deflecting them into the vallecula.

In this respect the *velum palati* and the epiglottis may be regarded as reverse counterparts of one another, expiratory currents "folding" about the palate much as inspiratory currents "fold" about the epiglottis. Both of them produce some eddies. (Justification for the term "folding" may be found in the illustrations. Cf. Figs. 5 and 7.) *The aryepiglottic folds* present smaller airfoils, setting up minor deflections in both inspiratory and expiratory currents.

Fig. 14.—Thermocouple, showing the protecting vinylite sheath with perforations opposite the joint.

INSPIRATORY CURRENTS

Passing through or over the above structures experimental smoke streams can be seen to pursue the following courses:

Inspired air entering the external naris proceeds toward the septum for one centimetre at an angle of approximately 20° to the sagittal plane then parallels it approaching the olfactory fissure between the septum and the middle turbinates in a practically vertical path. Fanning out in a high curve at first, the currents straighten and converge as they approach the choana. Once through that opening they are deflected sharply downward between the posterior wall of the pharynx and the posterior surface of the *velum palati.*

Reaching the margin of the velum a small portion of the current curls sharply around it and enters the mouth close to the palate.

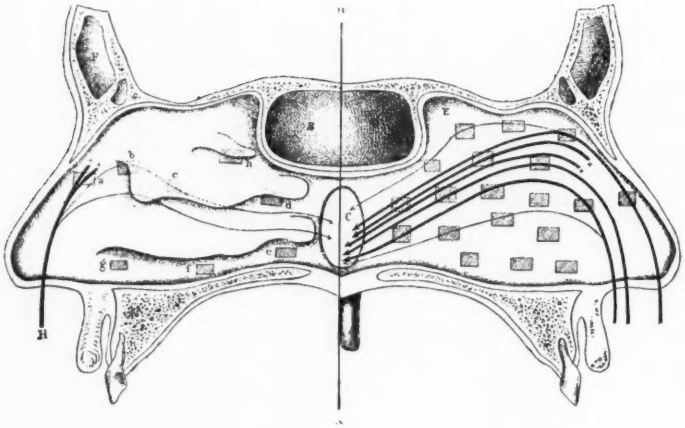

Fig. 15.—Paulsen's diagram of the inspiratory nasal air currents, determined by means of ammonia fumes and litmus paper. (From Zwaardemaker, Physiologie des Geruchs, Leipzig, 1895).

Another, much larger, portion eddies against the base of the tongue. At the margin of the epiglottis still another portion is deflected anteriorly by that structure, follows its lingual surface to the vallecula where it turns abruptly forward against the base of the tongue and into the mouth. In a series of spirals and eddies these diverted streams rejoin the main current to be carried into the larynx. A small eddy fills the pyriform fossa (Fig. 5-6).

Viewed from behind, the air currents proceeding back through the nose as described above, enter the pharynx through the choana and are turned sharply downward as they meet the pharyngeal wall. The main stream narrows progressively as it approaches the laryngeal chink in a straight line. The lesser streams deflected by the *velum palati* and the epiglottis are slower than the main stream and spread first forward and then laterally as they impinge upon the base of the tongue, then swirling back into the pharynx at the sides they proceed in a curved pathway to rejoin the main stream at the larynx (Fig. 11).

EXPIRATORY CURRENTS

Entering the hypopharynx and then the oropharynx the air currents follow in the main the same pathways as the inspiratory except, of course, that the direction of flow is reversed. The larger

eddy about the *velum palati* is somewhat flatter than its counterpart in inspiration and lies in a transverse rather than a posterior-anterior plane. Air passing up from the vallecula describes roughly a figure-eight curve in joining the upper eddy to escape with it behind the palate (Fig. 8).

From the nasopharynx, through which a single stream flows rapidly upward, the air is deflected sharply forward along the rostrum of the sphenoid and is divided into right and left halves by the posterior edge of the septum. Each half again is divided into two main streams, by the posterior end of the middle turbinate.

The first stream passes mesial to the turbinate and divides once more, part of it following the inspiratory pathway and emerging from the nostril; part of it forming a large flat eddy in the sagittal plane before emerging.

The second passes into the middle meatus. On leaving this space at its anterior end this stream also divides in two and, like its counterpart, enters the nostril partly directly and partly after eddying. The eddy in this case is not circular but an elongated ellipse remaining below the level of the margin of the middle turbinate.

There is a triangular "dead" space above the posterior end of the soft palate, in which there is almost no air movement. There is also a small eddy in the sphenoethmoidal recess.

Seen from the back, in the model prepared for this approach, the pathways described in the pharynx are approximately the reverse of those of inspiration except that they are flatter and wider and the main stream directed now by the posterior edge of the epiglottis is more diffuse than its inspiratory counterpart (Fig. 13).

As the speed of the air streams is increased by forced breathing the eddies appear to lose their identity, but this is only apparent since the streams tend to merge, reducing the definition of the smoke masses making them difficult to photograph in satisfactory contrast. Actually the pathways continue very much as described.

The peculiarities of individual noses have surprisingly little effect, the important factors in streaming being the all-over shape of the nasal cavity and the three air-foils, namely, the epiglottis, the *velum palati* and the posterior tip of the middle turbinate, all of which are relatively constant.

While the size and shape of the anterior nares determine the sharpness of impact of the inspired air they have less effect upon the

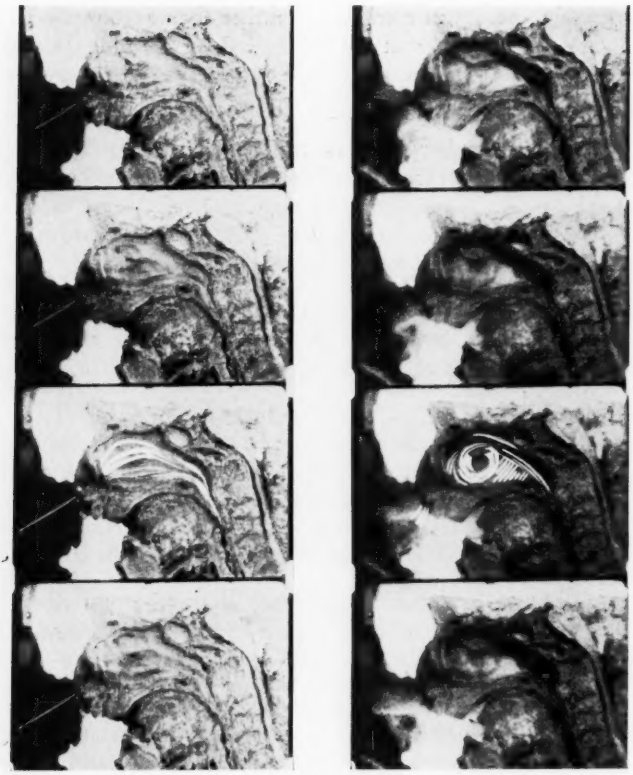

Fig. 16.—Motion picture sequences showing inspiratory (left) and expiratory (right) currents in the cadaver. The third frame on each side is retouched. (From the author's "Applied Physiology of the Nose," 1941.)

direction than one might gather from the writings of the plastic surgeons. So long as the initial stream enters in a generally upward direction it soon adapts itself to the standard pattern. The usual deformities have relatively little influence on this upward flow; in order to direct the flow backward, instead of up, it is necessary not only for the nostril but also for the constriction 1 cm internal to it to be dislocated to an angle approaching 90.° When through a congenital defect or a luetic deformity or following a severe accident this does occur then the condition simulates that described further on in this article as characteristic of upper nasal obstruction.

Fig. 17.—Diagram indicating the points of maximum impingement. At these points are 1) the pharyngeal tonsil, 2) the faucial tonsil and 3) the lingual tonsil. There is some turbulence above the larynx as well.

OBSERVATIONS

From the foregoing, three noteworthy observations emerge:

1. That through the agency of the *velum palati* and the epiglottis, the base of the tongue and whatever part of the oral cavity is momentarily accessible play a part in heating, moistening, and cleaning the inspired air.

2. That cold, dry, contaminated, inspired air does not come in contact with the sinus ostia, at least not in any direct stream, but that air currents reaching these openings are all expiratory and therefore moist, warm and clean. In this connection it is significant that the ostium of the frontal sinus, which would otherwise receive the brunt of the inspiratory current direct from the nostril, is safely tucked away behind the middle turbinate even though a long and tortuous passage is required for the purpose; while the ostia of the sphenoidal and posterior ethmoidal cavities lying, as they do, out of the line of fire, have no such protection.

It is more than likely that infections from the lower respiratory passages may be carried to the meatuses in these currents, especially in coughing.

3. That the three impingement points in the system are also the sites of the principal lymphoid tissue accumulations which constitute the "ring of Waldeyer" (Fig. 17).

At the first impingement in the nasopharynx is the pharyngeal tonsil; at the second, the base of the tongue, is the lingual tonsil; and at the third, beneath the *velum palati,* is the faucial tonsil. It will require someone more astute than the present author to establish a causal connection here, but the facts are more than suggestive.

That the tongue, the palate and, if they are exposed, other portions of the mouth participate in heating inspired air has been verified by measuring the temperature of these surfaces during inspiration, expiration and rest. Measurement of temperature differentials of the air currents themselves at various levels has been somewhat more difficult, but while quantitative figures are inconstant, since conditions vary from moment to moment they point to the same conclusions:

Room temperature	21° C.		9° C.	
Air, static, in mouth	35.5		35.5	
	Insp.	Exp.	Insp.	Exp.
.5 cm from post. wall	33.5	35.5	32.2	35.5
1.5 cm from post. wall	34	35.5	33.5	35.5
3.0 cm from post. wall	35	35.5	34.8	35.5

(Figures recorded are the maximum and minimum temperatures attained during the natural respiratory cycle.)

COMMENT

One can not help being impressed with the fact that among noses considerable variation can exist without much effect upon the general pattern of the air streams, the general contours being responsible for them as stated above.

The same is true of variations in pressure; swift streams tend to obliterate the identity of the various components without materially changing their directions.

Everything discussed above relates to the uninterrupted relaxed or forced breathing in the normal tract. In the life of the average

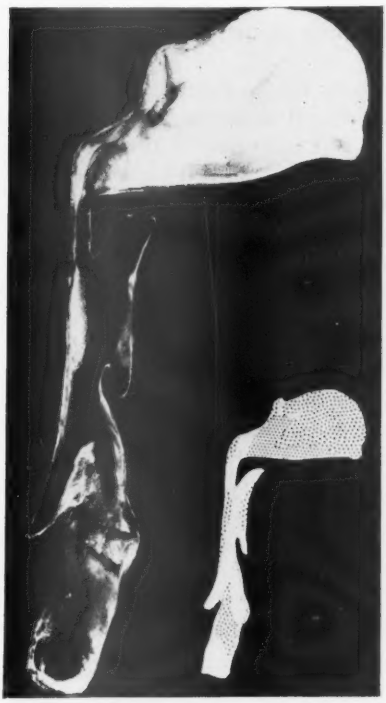

Fig. 18.—Photograph showing deposits of air borne powder left on the surfaces of the model by passing inspiratory currents. The deposits correspond with areas of turbulence and impingement.

human these conditions obtain fully only during sleep or during concentrated sedentary employment. Talking, singing, swallowing, smoking, straining during heavy lifting, and the dozen or more useless movements of mouth throat and nose which make up individual idiosyncrasies interrupt the airflow during much of the time.

Actually, if one's observations are correct, only two major variations occur, namely, the repeated abrupt interruption of the nasal expiratory current by the closure of the palate during speech and the auxiliary use of the mouth at such times for quick inspirations. Even this latter does not hamper the humidification and heating of air according to Perwitzschky[5] who maintains that the mouth is only slightly less effective than the nose as an air conditioner. Using the smoke apparatus with the sagittal model described above the flow

was repeatedly and abruptly interrupted to reproduce as nearly as possible the valve action of the soft palate in speech.

With each closure the air streams were halted "in their tracks" only to continue without distortion as soon as the passage was reopened. This went on regardless of the frequency of interruption. It could not be recorded in a "still" photograph but shows well in the motion pictures.

During coughing the nasopharynx is usually shut off, the explosive blasts of air passing through the mouth. Sneezing on the other hand takes place via the nose and mouth, and sometimes unfortunately via the eustachian tubes.

It has sometimes been said that a public speaker who reaches for a glass of water to "wet his whistle" is resorting to a purely psychic maneuver since the water does not reach his whistle but by-passes it to the gullet. This is of course fallacious. During a speech, inspiration consists largely of mouth-breathing, so that wetting a dry mouth and pharynx is temporarily useful.

Several details of minor interest developed through the use of the impingement model in which deposits of air-borne particles were allowed to accumulate (Fig. 18).

First, the largest deposit of all was in the nasal chamber proper, where it occurred by virtue of the constriction within the nostril, the narrowness of the olfactory fissure and the curvature of the passage.

Second, heavy deposits accumulated at the other impingement points described above, as was to be expected.

Third, very little deposit accumulated immediately behind the soft palate where there was a constriction and the current was swift.

Fourth, a relatively heavy deposit occurred on the back wall of the oropharynx corresponding to the deposits in the constricted glass tubes *after* the stream has passed the constriction and also corresponding to site of the beginning sore throat.

Fifth, there was a sharply defined deposit in the area of the lymphatic tissue sometimes termed "the laryngeal tonsil."

PART II. ABNORMAL CURRENTS

Aberrations of the respiratory air currents are almost certain to produce deviations from the physiological state of the nose and throat. Some of these are severe enough to be incapacitating; many of them are scarcely noticeable or are so minor as to be overlooked at examination.

Trouble may arise from changes in the air itself (e.g. low humidity), from changes in the character of the mucosa or from physical obstructions and deviations.

The optimum relative atmospheric humidity for nasal function lies between 35% and 45%. Departures from this concentration are well tolerated by the mucosa until the humidity falls to around 23% when the more susceptible patients begin to complain. With a drop to 16-18% most noses suffer.

Currents passing through in the normal pattern then produce drying, first at the impingement points in the nasopharynx, about the uvula and the base of the tongue, later over the whole area and especially in the nasal vestibule where inspissated secretions accumulate and harden.

Similar effects may be found in noses with atrophic membranes or membranes prevented by some systemic deficiency from turning out mucus of the proper moisture content.

With the advent of cold weather and furnace heat, nasal discomfort is a common complaint. At this season nasal infections multiply and increase in severity owing to the local stasis of mucus masses bearing bacteria.

In this connection it is noteworthy that the mucosa on the medial side of turbinates in adults, especially in city dwellers, having been exposed to much infection and irritation undergoes metaplasia to the pseudo-squamous type, while the protected mucosa of the meatuses does not. Ciliary activity is commonly more brisk in the protected areas than in exposed ones. It has been shown[1] that the nasal mucosa in laryngectomized persons, even in those of advanced age, returns to normal (including the columnar ciliated epithelium) after it has been relieved of the damaging influence of inspired air for a period of a few months.

As has also been pointed out[7] the protecting nasal mucous blanket conveyed at the usual speed across the surface of the epithelium by the cilia traverses approximately ten epithelial cells per second so that, under the circumstances, organisms do not remain in

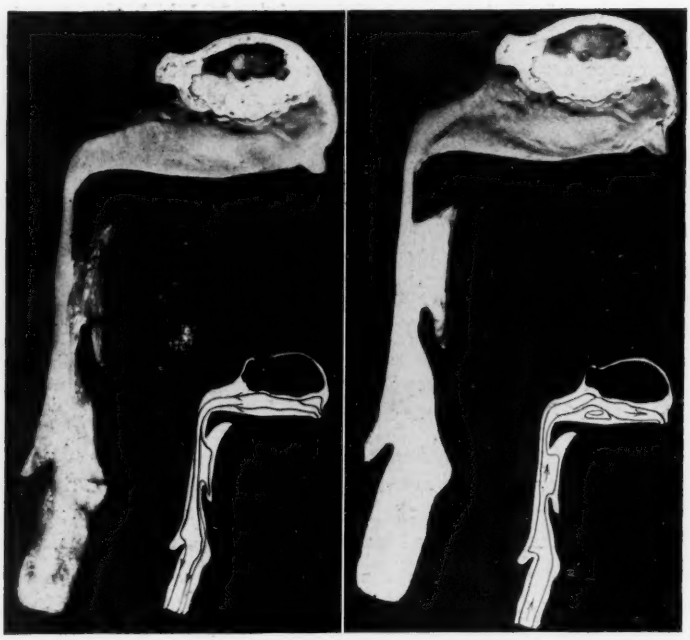

Fig. 19.—Inspiratory currents in the presence of upper nasal obstruction.

Fig. 20.—Expiratory currents in the presence of upper nasal obstruction.

the neighborhood of any given cell longer than 0.1 second—a period too short to permit infection to take place.

In a normally proportioned nasal cavity then, the damage done by dry air or dry membrane, or a combination of the two, is apt to be generally distributed.

In the case of a local obstruction or distortion the disturbance also will be local. Such a spot should be discoverable both through the subjective sensations of the patient and through the presence of a piling up of drying mucus somewhere in the nose or throat.

Two common locations are the nasopharynx (where a dry spot presages a sore throat) and the vocal cords which become parched and produce a hoarse voice, or none at all. Certain patients are subject to spells of aphonia because the architecture of their throats permits an abnormal impact of dry air upon the larynx.

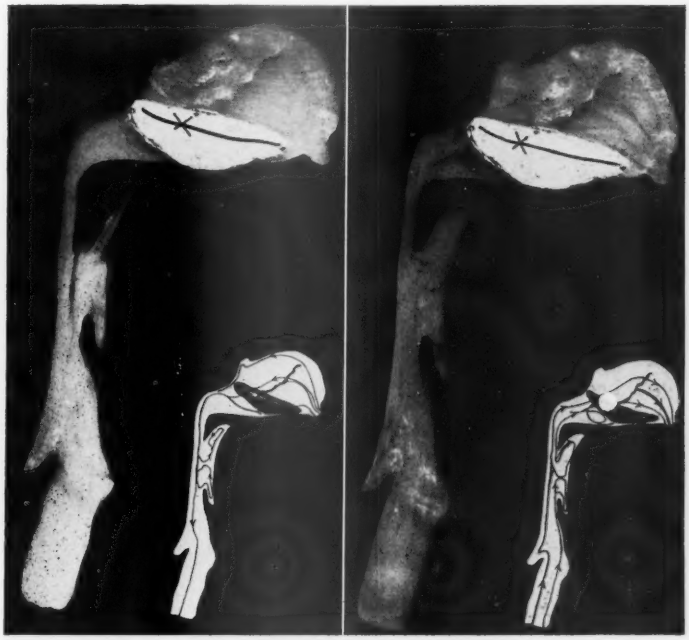

Fig. 21.—Inspiratory currents in the presence of a septal spur.

Fig. 22.—Expiratory currents in the presence of a septal spur. (The base of the spur is toward the observer.)

For the purpose of studying the effect of nasal swellings and distortions upon the air currents and their impingement points, small soft rubber molds were constructed to fit into the models described in Section I.

The Anterior Naris. The chief disturbances here resulted from narrowing or collapse rather than from any deviation in the direction of the entering air-jet. While the obstructions were common it was found that only a very pronounced change in the external nose, such as a complete saddle-nose deformity or post traumatic distortion, prevented Bell's constriction or "nozzle" from pointing upward in the proper direction.

The obstructed naris appears more likely to cause trouble through augmenting the positive and negative respiratory pressures than by changing the direction of the stream.

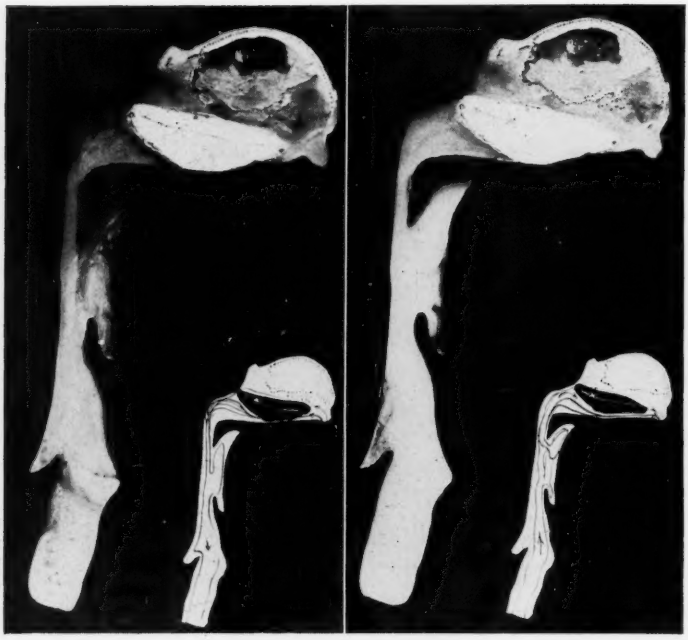

Fig. 23.—Inspiratory currents in the presence of both upper obstruction and septal deflection.

Fig. 24.—Expiratory currents in this condition.

High Swelling. Clinically the most significant as well as the most common of the obstructions is that involving the whole upper nasal chamber and caused by a simple widespread swelling of the mucosa: the ubiquitous "stuffy nose."

In this condition not only is the upper two-thirds of the nasal chamber eliminated from the total evaporating area, but the inspired air, instead of fanning out over the turbinates, makes straight for the nasopharynx in a concentrated stream. There it produces dryness and stasis of the mucus blanket, and deposits its particulate matter in a heap.

Such a condition is the very frequent forerunner of the common cold. The swelling high up which produces it, is itself the result of some systemic or local cause, such as fatigue, constipation, digestive upset, menstruation, allergy, sudden chilling of the body surface, industrial fumes, house dusts and a host of other general

Fig. 25.—Inspiratory currents in the presence of polypi in the middle meatus.

Fig. 26.—Expiratory currents in this condition.

or local irritants. The stuffy condition is generally described by the patient as a "beginning" cold although it is actually only a precursor. If the physician can eliminate this high obstruction within the first few hours of its existence the cold will be aborted or, more accurately, will never begin.

The air currents in this condition are shown in Figs. 19 and 20. It will be seen that in the presence of such an obstruction the air conditioning function of the nose becomes greatly impaired.

Septal Spurs and Deviations. Contrary to expectation and to the general impression, the so-called plow-share shaped spur, when it exists alone has scarcely any effect on the air currents. This is owing to the fact that its shape, its thinness and its location streamline it to the passing air current. From Figs. 21 and 22 it will be seen that the currents are practically identical with those in Figs 5 and 7, which depict the normal.

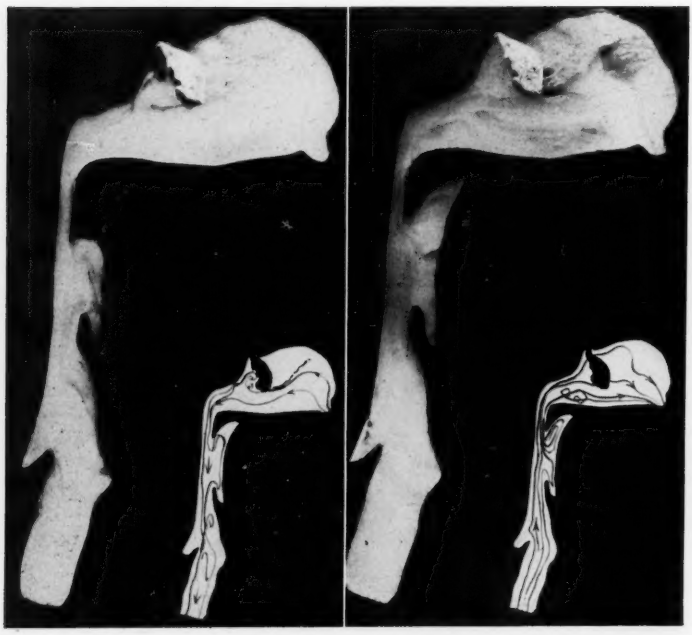

Fig. 27.—Inspiratory currents in the presence of polypi in the superior meatus.

Fig. 28.—Expiratory currents in this condition.

Only when this spur is combined with a swelling of the lateral wall bringing about a pronounced obstruction is the air pattern altered. Figs. 23 and 24 show this condition. Now the air stream, much reduced, gets through anywhere it can; the impingement points are small, usually insignificant and the characteristic symptom is mouth breathing.

The same may be said of deviations, since their effect is chiefly conditioned by size, shape and location with reference to the normal air pattern.

A deviation as such is not symptom producing, provided the lateral walls are so related to it as to permit even and unimpeded passage of air. Attempts at adjustment and restoring the septum to the midline are not only superfluous but will result in upsetting the air balance and producing symptoms of local drying and irritation.

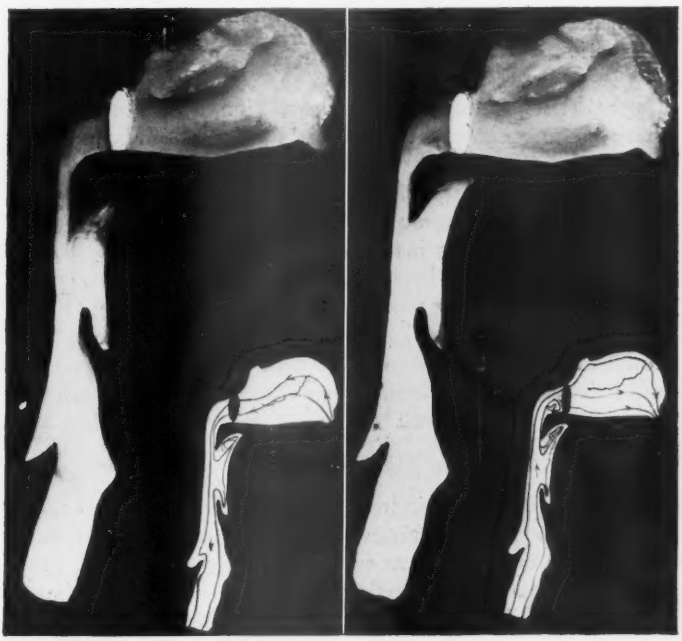

Fig. 29.—Inspiratory currents in the presence of a hypertrophied plica septi.

Fig. 30.—Expiratory currents in this condition.

What has been said regarding spurs and similar obstructions pertains only to their effects upon air currents. Impingement with pressure upon surrounding structures is a separate problem, to be dealt with as such.

Polyps and local hyperplasias cause deviations in the air patterns according to their locations. Troublesome as they may be in other respects polyps confined to the middle meatus have little effect on the air streams (Figs. 25 and 26).

Polyps about the posterior ethmoidal ostia, in the superior meatus are much more apt to deflect them. Inspired air is deviated downward, away from the face of the sphenoid, and the currents high in the nose in front of the obstruction are apt to be retarded and diminished (Figs. 27 and 28). It is well known that reduced ventilation can effect the nasal mucosa as well as excessive ventilation, though

in a different way.[2] Eddies are sometimes set up against the face of the sphenoid and the region of the sphenopalatine ganglion, causing obstruction, or headache, or both.

Hyperplastic plica septi. This obstruction, owing to its location may have the specific effect of diverting the stream laterally and projecting it against some portion of the eustachian orifice. Since hyperplasia of the *plica septi* is regarded as a result of persistent irritation of the area by chronic discharges from the sphenoid sinus it is difficult to determine whether or not this hyperplasia is instrumental in bringing about hyperplasia of the lymph nodes surrounding the tube, or is merely coincidental with it, emanating from the same source. However, the lateral projection of air currents against the mouth of the tube can be made out in the models (Figs. 29 and 30) and it is reasonable to assume that the drying effect there would be irritating as it is known to be elsewhere. Clinical data are wanting.

Local dry spots. The index to the role which aberrant air currents may be playing in a given case is the localized and persistent dry spot. This can sometimes be identified by the glazed appearance of the mucosa which elsewhere appears normal. Sometimes the patient can point the way to it by describing his sensations. When the secretions are purulent the search presents no difficulties because there is a piling up, sometimes a crusting, of mucopus. Such spots may appear almost anywhere in the upper respiratory tract, but most frequently produce symptoms when they are on the posterior wall of the nasopharynx, on the face of the sphenoid, about the eustachian orifice, at the edge of the epiglottis or in the larynx. Such dry spots have been experimentally produced and studied, in the rabbit nose.[9]

The illustrations from models, accompanying this article, are from photographs made at 1/5000 second. Smoke currents caught at a given instant during their passage through the channels can give only an imperfect idea of the swirling and beating against the walls occurring when the normal flow is diverted or impeded. Motion pictures in color have been made, permitting repeated observation of details, from which the above data were taken.

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XLII

THE PRESENT STATUS OF TRACHEOTOMY IN BULBAR POLIOMYELITIS

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In 1946 a devastating epidemic of poliomyelitis occurred in Minneapolis. Physicians were faced with problems seldom equalled in quantity or quality. These problems were solved in the manner which seemed most sensible at the time. Among measures used was tracheotomy in cases of bulbar poliomyelitis having secretional obstruction of the pulmonary airways. At the end of the epidemic results were tabulated and accounts of experiences were published in the belief that the reports might be useful to others. As might have been anticipated the reactions of the medical world were varied. Some authors took issue with the Minnesota group saying its treatment of certain cases had been too radical and might even have prejudiced the chances for recovery of some patients. Other commentators agreed with the Minnesota group. The purpose of this paper is to assemble all the reports brought out since 1946 and to assess the value of tracheotomy in bulbar poliomyelitis in light of these reports. Among the reports giving rise to controversy was that of Priest, Boies and Goltz[24] on tracheotomy in bulbar poliomyelitis.

This paper reported experiences in an epidemic of 1830 cases. About 400 were "bulbar." 75 of these had tracheotomies. 29 sur-

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vived and in 19 cases it seemed that tracheotomy had been a decisive factor in the recovery.

Although the original series contained only 75 cases of tracheotomy in bulbar poliomyelitis, it was by far the largest single group at the time of publication. Miller and Buck[22] have since reported 181 tracheotomies in polio patients, and papers on many smaller series have also been published. The present paper reviews many of these reports and outlines today's attitude toward tracheotomy in bulbar poliomyelitis. Experience since 1947 at the University of Minnesota are presented.

Because medical indices have been published irregularly since World War II magazine articles have been hunted out by scrutinizing pertinent journals. Some papers have undoubtedly been missed. This has been unintentional. All papers known to us have been included.

About 26 papers on tracheotomy in bulbar poliomyelitis have been published since 1946. These papers fall into several groups. Quite a number favor tracheotomy in bulbar poliomyelitis but their authors report no personal experience with the method. A few papers express definite opposition to the method but have never used it. One paper recognizes the method but the author has seen no need for it in his own large experience. Several physicians from many quarters of this country and from Europe and Australia report favorable experiences with tracheotomy in bulbar poliomyelitis. In the ensuing discussion the papers are classified according to the opinion of their authors on the use of tracheotomy in bulbar poliomyelitis.

Papers favoring tracheotomy but reporting no experience are discussed first. Warder,[3] (Anderson, S. C.) while discussing tracheotomy in general says "The number of tracheotomies done too late far outweigh those done unnecessarily." This point should be considered seriously by any physician who is deciding for or against tracheotomy for any patient.

Irwin[4] (Jacksonville, Fla.) indicates that he believes bulbar poliomyelitis constitutes an indication for tracheotomy, although he does not describe any experience with the procedure in poliomyelitis.

Henson[5] (Charleston, W. Va.) says that "by resorting to tracheotomy early, when signs of involvement of the ninth and tenth

cranial nerves are present in poliomyelitis and by judicious use of oxygen and suction through the tracheal tube, many lives may be saved."

Stimson[7] (New York) in 1947 said that "tracheotomy under local anesthesia may prove lifesaving by providing a by-pass for oxygen to the lungs, especially when the vocal cords are relaxed together or there is much mucus in the trachea." Stimson goes on to comment favorably on tracheotomy in poliomyelitis as used in Minneapolis in the 1946 epidemic.

Viets[16] (Boston, Mass.) said, "The most important decision to be made immediately is in regard to tracheotomy. If the patient is having a continuous problem in eliminating saliva and bronchial secretions, a tracheotomy should be seriously considered. The maintaining of an unobstructed airway is of first importance; if this cannot be done by postural drainage and aspiration, tracheotomy must be carried out."

Viets[16] continued, "After tracheotomy, the patient with bulbar poliomyelitis requires expert care and special nurses are needed. It is necessary to continue the aspiration of the accumulation of fluids in the pharynx and the tracheal cannula must be inspected and cleared frequently. If the tracheal secretions become viscid, an attempt may be made to humidify the inspired air. The most successful method is to deliver moist air and oxygen mixtures directly into the tracheal tube by a tracheotomy inhalator, a method devised by the Minneapolis group."

Simpson and Witcher[18] (Memphis, Tenn.) indicate that they would use tracheotomy in poliomyelitis to "provide easy access to the pulmonary tree for aspiration of pathologic secretions."

Bouman and McDonough[19] (Madison, Wisconsin) commented favorably upon tracheotomy in bulbar poliomyelitis. They favored Kubicek's[13] method of administering oxygen and helium through the tracheotomy tube with the respirator.

One paper expresses neither favor nor opposition to the use of tracheotomy in bulbar poliomyelitis. Hoyne[11] writing from the Cook County Contagious Disease Hospital in 1947 says, "The primary object in the case of bulbar patients is to prevent nose and throat secretions from passing into the trachea and ultimately re-

sulting in pneumonia. To prevent the patient from drowning in his own secretions continuous suction is often required. Tracheotomy has been recommended but thus far we have not considered the operation indicated."

Two authors take issue with those advocating the use of tracheotomy in bulbar poliomyelitis. Stimson[8] at the First International Poliomyelitis Conference in 1948 said that he "visualized circumstances where tracheotomy certainly must be done," but said "we have not yet found a patient where we have had to do a tracheotomy." He outlined various possible indications for tracheotomy and commented on methods of handling these problems without use of tracheotomy.

Stimson[8] commented further: " . . . There are two 'indications' that I do not think are necessary. One of them is inability to cough per se, that has been listed as an indication for tracheotomy. We do not feel at all that that by itself is an indication for tracheotomy. The other one is the patient who develops cyanosis while in a respirator. That frequently is due to atelectasis and tracheotomy is of no value in atelectasis."

Consider Stimson's comment on "inability to cough per se" as an indication for tracheotomy. Priest, Boies and Goltz[24] said "inability of the patient to clear his own airway was indicated by recurrent cyanosis, coarse, bubbling rales in the chest, laryngeal stridor *and inability to cough efficiently*." It should be obvious that the entire clinical picture must be viewed and that no one sign or symptom constitutes an indication for tracheotomy.

Next consider Stimson's statement that "tracheotomy is of no value in atelectasis." This is inaccurate. Atelectasis is due to bronchial obstruction by accumulated intrabronchial fluid in most instances. Aspiration of the fluid to permit re-aeration of the lung relieves the atelectasis. The aspirating tube may enter through a laryngoscope or bronchoscope or tracheotomy. It should be obvious that one would choose the simplest method for introducing the aspirating tube consistent with the welfare of the patient. In cervical spine injuries when bronchoscopy could cause movements endangering the spinal cord tracheotomy has been used by the authors to relieve atelectasis. In jaw fractures, brain injuries, drug poisoning and botulism[25] atelectasis has also been relieved by aspirating cath-

eters passed through tracheotomy tubes. Thus tracheotomy actually is of value in atelectasis, Stimson to the contrary notwithstanding.

In 1949 Wesselhoeft[20] (Boston) commented on the use of tracheotomy in bulbar poliomyelitis. He said, "On the question of tracheotomy, my opinion remains unshaken. I have had occasion to perform many tracheotomies in the course of 30 years of service on the staff of a contagious disease hospital, and I have had the aftercare of many tracheotomies performed by our surgical staff. During these 30 years I have yet to see the case of poliomyelitis that I thought required tracheotomy. This operation has been discussed by the staff on several occasions, both in connection with living cases and at the autopsy table, but never have I been convinced that the indications were present. To my mind, the indications consist of structural obstruction to the airway. In bulbar poliomyelitis I have not been confronted with structural obstruction either from swelling of the parts or spasmodic contractions. The obstruction which occurs is from secretions. The patient cannot swallow, cannot close the glottis, and is, therefore, unable to cough. Postural drainage and gentle, skillful suction are indicated."

He commented further on the discussion by Priest and Baker[29] at the First International Poliomyelitis Conference in New York that, "there was criticism of the indications given and especially of the readiness to perform the operation early to prevent future obstruction through laryngeal stridor. It was pointed out that these authors failed to emphasize the value of postural drainage. Wilson, who had been a pioneer in advocating this operation when he was at the Boston Children's Hospital, felt that the operation had been effective in saving the life of a very few patients, but he could not accept the indications for this operation as expressed by Priest and Baker. In the opinion of Wilson, the chief indication consisted of extreme restlessness due to inability to establish sufficient airway by means of postural drainage and suction. Stimson, Shaw, Pierce and Anderson, all with extensive clinical experience in all phases of this disease, expressed a reluctance to endorse the enthusiasm for tracheotomy emanating from the Minneapolis group. It is impossible to gauge the value of this operation when performed early, because there is no way of knowing whether it actually saved a life or whether the patient recovered in spite of the added risk of the operation. Tracheotomy is a hazardous undertaking. Perhaps those of us who

have had no experience with tracheotomy in bulbar poliomyelitis are not in a proper position to speak against it. It is always possible that the Minneapolis cases presented a peculiar genius epidemicus that warranted this operation, but this is certainly not made clear to most of us who are familiar with the indications and value of tracheotomy in other infections and with the care of the many phases and manifestations of bulbar poliomyelitis."

Wesselhoeft[20] writing in 1949 apparently had not read the paper of Priest, Boies and Goltz[24] published in 1947. In Wesselhoeft's[20] statement that "these authors had failed to emphasize postural drainage" there is, in Mosher's[26] words, "a grain of truth but only a grain." Priest, Boies and Goltz[24] had not emphasized posture because they had found that patients did not long tolerate the best position for decanting fluid from their tracheas. The angle made by the trachea with the long axis of the chest necessitates a head-low posture to get the caudal end of the respiratory tree high enough to empty fluid out of it. Polio patients become very rapidly fatigued in this position. Rest and sleep are most important to the polio patient as emphasized repeatedly by Wilson. In the mild case postural drainage is of course worth trying but expecting it to do the whole job in the severe case is asking too much.

In 1947 Priest, Boies and Goltz[24] discussed "unsuccessful methods of aspiration" at length. Continuous and intermittent pharyngeal suction, O'Dwyer tubes, water suction, types of pharyngeal catheters, intratracheal tubes and various suction pumps were considered. Postural drainage should have been included in this part of the paper since it had been extensively tried out. Galloway[30] has written fully on this phase of the treatment of poliomyelitis.

Wesselhoeft's[20] comment that "there was criticism of the indications given and especially of the readiness to perform the operation early to prevent future obstruction through laryngeal stridor" should be put into proper focus. Laryngeal stridor had not been advocated as a lone indication for tracheotomy but only in conjunction with "recurrent cyanosis, coarse, bubbling rales in the chest and inability to cough efficiently." Wesselhoeft's statement that "it is impossible to gauge the value of the operation when performed early, because there is no way of knowing whether it actually saved a life or whether the patient recovered in spite of the added risk of the operation" had been covered adequately in the 1947 paper and is self evident.

On the other hand, it seems that withholding the operation and allowing the patient to die to prove that he actually will die is, again in Mosher's phraseology,[26] "being a purist to the point of sterility."

Papers reporting satisfactory results with the method will now be discussed. Weiland, Burbacher and Keiser[2] (Coral Gables, Fla.) in 1947 said that "to aid in keeping air passages open, a tracheotomy may be performed. We feel that in selected cases the procedure is of definite value and should be utilized. . . . There is no question that suction through a tracheotomy tube is more efficacious in keeping the air passages clear than in the oral route. . . . We do not recommend it routinely in bulbar cases as some do, but we are fully aware of its value and have utilized the procedure in several cases to great advantage."

McLorinan[6] reported three cases of tracheotomy in bulbar poliomyelitis. He says, "One patient died, and the recovery of the others is considered to have been influenced favorably by the operation of tracheotomy." McLorinan's case reports are particularly fine and afford profitable reading. In one case he used an endolaryngeal tube to relieve adductor spasm as evidenced by laryngeal stridor and a change in the voice. This tube became blocked with mucus and tracheotomy was carried out. McLorinan said, "This gave complete relief." The patient went on to recover.

In his second bulbar poliomyelitis case McLorinan performed tracheotomy when his patient became restless and cyanotic. He evacuated "thick greenish pus from the trachea." The patient developed intercostal and diaphragmatic paralysis and was put into a respirator. Here she improved although her "trachea became blocked frequently." Twenty days later she was decannulated; she recovered.

Peterson and Ward[16] reported on 400 poliomyelitis patients at St. Luke's Hospital in Boise, Idaho. They said, "It is our opinion, from our experiences in this epidemic, that tracheotomy when properly indicated has been a life saving procedure."

Baker[2] (Minneapolis) reported at the Rocky Mountain Conference on Infantile Paralysis that "in many cases the lesions involve primarily the cranial nerve nuclei. These patients often develop respiratory difficulty due to laryngeal obstruction. In such cases tracheotomy, properly instituted, can often be a lifesaving device."

Piszczek[10] of the Cook County Department of Health, Chicago, said, "The decision whether or not a patient can be benefited by tracheotomy is a very serious matter. A tracheotomy may be of great value when the patient has a continuous problem with his salivary and bronchial secretions. In a recent epidemic, the combination of tracheotomy, respirator, helium and oxygen were used to good advantage in the saving of human life. I have observed several almost miraculous recoveries following tracheotomy, while on the other hand I have seen a few fatalities immediately after surgery. I feel, however, that if there is a consistent "drainage" problem of the salivary and bronchial secretions a tracheotomy should be done."

Galloway[9] (Evanston, Illinois) said that "anoxia due to accumulated secretion is a most important factor in bulbar poliomyelitis. Early and adequate care, administration of oxygen, proper postural drainage and aspiration will often suffice for recovery. With increasing signs of anoxia, further intervention must be weighed. Although the following recommendations are perhaps to be considered only tentative on the basis of present understanding of the disease, it seems that indications for tracheotomy in poliomyelitis should be definitely set up. These are my own convictions, fortified by the thorough study of Priest, Boies and Goltz[24] of a large number of cases, and I believe them to be conservative. The indications for tracheotomy in poliomyelitis are:

1. Fluid in the upper airway, with signs of anoxia increasing in spite of the administration of oxygen, postural drainage and aspiration. Restlessness, dyspnea, cyanosis, disorientation and mental depression are important determinants.

2. Unconsciousness or marked restlessness in a patient not previously treated and not responding to other treatment in a few minutes.

3. Marked restlessness or stupor in a patient in a respirator even if he apparently has a spinal type of poliomyelitis.

4. Fluid accumulation not otherwise easily and certainly taken care of in a patient requiring the respirator.

5. Rapidly progressive bulbar symptoms, as recommended by the Minneapolis group. Most of our patients in this group had had an onset with severe vomiting.

6. Bilateral paralysis or spasm of the vocal cords.

7. Markedly increasing signs of vasomotor failure not explained as due to a cause other than anoxia.

8. Untrained or inefficient attendants, inadequate equipment, or poor cooperation of the patient, with doubt that the airway will be kept constantly free of secretion."

Galloway continues: "Tracheotomy is more necessary when the attending team has had little experience with the disease. If all the personnel were thoroughly trained and the mechanical arrangements perfect, tracheotomy might be seldom required. But unforeseen failures occur too easily. For instance, an assistant substituted, against orders, a fine medicine dropper tube for a proper glass connecting tube and thus prevented proper aspiration, which made an emergency tracheotomy necessary. In another instance an untrained attendant relieved the experienced nurse. Poor aspiration during two half-hour periods led to anoxia from which a decerebrate state developed."

Wilson[17] in 1948 gave a rather extensive discussion of tracheotomy in bulbar poliomyelitis which is worth quoting here. It follows: "Tracheotomy is a radical step but often life saving. Its purpose is to furnish a free airway so that the air necessary for respiration does not need to be moved down a pharynx full of secretions and through a larynx continually in spasm. Tracheotomy is often dramatically effective. One need not comment on the dangers of tracheotomy such as from pneumothorax and infection, although the latter danger is lessened now with our effective antibiotics. One should attempt to carry out tracheotomy long before severe choking attack or attacks of cyanosis make it obviously necessary as a last desperate attempt to save life. The indication, therefore, depends upon the success of the other two forms of treatment, postural drainage and aspiration, in keeping the pharynx clear. Although the pharynx may be clear enough by these techniques to prevent only occasional choking, if it cannot be kept clear enough so that the patient can also get rest, a tracheotomy should be carried out. One should consider the seriousness of the situation in a patient with pharyngeal paralysis whose every breath must be a consciouly calculated and planned one, with inspiratory muscles continually alerted to a sudden expiration, which will be initiated by even slight aspira-

tion. Such a patient gradually develops such extreme fatigue that he eventually lapses into unconsciousness even if this state has not resulted from aspiration and anoxia. These dangers must be prevented at all costs."

"There has been a recent wave of enthusiasm for tracheotomy. A tracheotomy most certainly is not necessary for every case of pharyngeal paralysis in poliomyelitis. In fact, in my experience, it is necessary in only a small fraction of all "bulbar" patients. There are many cases of palatal paralysis which simulate pharyngeal paralysis where obviously it is not necessary. Frequently, good results from careful and critical medical care can be obtained without resorting to a tracheotomy, but constant observation during the first few hours of contact with the patient is necessary to make it evident whether or not it will be necessary."

"In case of the majority of patients with mild or moderate brain stem involvement, successful treatment depends considerably on one's ability to get them to relax. One must make a serious effort toward avoiding excitement and giving a patient confidence. An otherwise simple situation can be rapidly changed for the worse when physicians and other attendants rush in an excited way around a room, hang a patient up by his feet to give him postural drainage, and thrust aspirators into his throat vigorously with an air of excitement. Although I realize the difficulty in distinguishing the results of treatment from the effects of the progressive disease itself, I belive fear in a patient will greatly prejudice his outcome. A calm but certain worker with an attitude of confidence can do a great deal to make the simplest means of treatment of this disease effective. In certain patients one can tell in a very few moments that they are going to be so tense that they will not easily submit to effective aspiration of the throat. Such a patient will probably need a tracheotomy. In deciding upon this important step, therefore, evaluation of a patient's emotional stability is just as important as any other part of the physical examination. Because of the very great emotional disturbance that some patients exhibit, it is tempting to resort to sedatives. It is doubtful that sedatives are ever justified because one is always uncertain how much of the excitement and fear is something that could be alleviated by a sedative and how much is actually due to anoxia or fatigue, as a direct effect of pharyngeal paralysis. Under such circumstances, a patient cannot be given the luxury of rest and a tracheotomy will be necessary."

"Although there is room for differences of opinion, in my own experience it is wise to carry out the tracheotomy under an anesthesia and in children, at least, avertin has seemed rather ideal. The excitement of tracheotomy done under local anesthesia can be followed by such rapid increases in the rate of the heart that one cannot avoid the feeling that it is a direct result of too great trauma and emotional stimulation." Wilson continues, "Much more could be said about the techniques of many procedures that have been outlined. How should oxygen be administered? With a tracheotomy, it is quite easy to administer oxygen with various types of apparatus such as a small cone over the tracheotomy opening. The greatest problem in any situation where there is a tracheotomy is to give the oxygen while at the same time leaving free access for observation of plugging of the tracheotomy tube with secretions and for aspiration."

Grulee and Panos[12] writing from the pediatric department of the University of Minnesota hospitals emphasized that in their cases "the decision for tracheotomy was reached only after careful appraisal by both pediatricians and otolaryngologists of all contingent circumstances and was necessarily based on relative, rather than absolute, indications. For example, 96 of 107 patients with bulbar poliomyelitis had demonstrable involvement of the tenth cranial nerve and 55 of these had definite dysphagia (20 patients had tracheotomies). Thus, the involvement of the tenth cranial nerve with or without dysphagia did not alone constitute a valid indication for tracheotomy, although it did serve as a signal for especially close observation. The presence or imminence of anoxia, as manifested by the following signs and symptoms, formed the basis for the decision to operate: irregular, shallow and periodically apneic respirations; exhaustion, agitation, restlessness or apprehension; progression of bulbar involvement, with increasing dysphagia, and the presence of suffusion, cyanosis and retraction of the chest wall. An attempt was made to anticipate the need for early tracheotomy by carefully weighing each of the aforenamed signs, since little benefit could be expected from the procedure in the presence of such obvious and late signs as extreme cyanosis, gurgling of aspirated fluids and retraction of the chest wall. Thus, it was felt that any patient manifesting rapid progression with difficulty in swallowing was a candidate for elective operation. Likewise, a patient who became agitated and apprehensive, in spite of continuing apparent success in man-

aging secretions, was considered to be showing signs of anoxia and, therefore, to be deserving of tracheotomy. The further adaptation of the oximeter to the study of oxygen saturations in such patients will doubtless expedite the decision for operation."

Grulee and Panos[12] based their report on 20 pediatric patients who were subjected to tracheotomy. 17 were boys and 3 were girls. All had involvement of the tenth cranial nerve with dysphagia. 10 died. Grulee and Panos[12] comment that, "There can be little doubt of the efficacy of tracheotomy in certain cases of the bulbar form with progressive involvement of the muscles of deglutition and respiration, but without extensive direct involvement of the respiratory and circulatory centers in the medulla."

Kubicek et al[13, 14] (Minneapolis) have contributed very significant papers on the physiology of respiration during poliomyelitis. They devised an efficient means for giving humidified oxygen under positive pressure through a tracheotomy tube. Photoelectric oximeter measurements were used to establish blood oxygen levels. Anyone treating bulbar poliomyelitis will profit by reading these papers.

Grulee et al[15] carried on a most illuminating round table discussion on all phases of bulbar poliomyelitis at the Pediatric Academy meeting in Dallas in 1948. One can become familiar with most of the points of view on bulbar poliomyelitis by reading this discussion. The statements by Wilson as part of this round table express a very common sense viewpoint on tracheotomy in bulbar poliomyelitis. Wilson[15] said, "Indication for a tracheotomy can best be expressed this way: When careful attempts at postural drainage and aspiration with a good apparatus, gently but firmly used and running at the right pressure, is ineffective in allowing the patient to rest and sleep, then a tracheotomy will be necessary. One should not wait for severe choking attacks with cyanosis to prove its necessity. Tracheotomy, however, is not necessary in all patients with pharyngeal paralysis. It certainly is not necessary in all patients who have to be placed in a respirator, and patients who have pharyngeal paralysis often are harmed by a respirator. One should carry out a combination of the two treatments only when both conditions that indicate them exist, that is, pharyngeal paralysis and respiratory muscle paralysis. There are times when it is extremely difficult to tell whether a patient's respiratory difficulty is due to central disturbance of the

respiratory center or pharyngeal secretions. In that case, a tracheotomy is justified even though it may prove to be ineffective."

Strobel and Canfield[21] (New Haven, Conn.) in 1950 reported on 10 patients tracheotomized for secretional airway obstruction in bulbar poliomyelitis. Half of their patients died. No death was attributed to the tracheotomy. The authors thought that tracheotomy was delayed too long in four patients whose lives might have been saved by earlier operation.

Miller and Buck[22] (Los Angeles) in 1950 discussed experiences with 181 tracheotomies in 351 patients having bulbar poliomyelitis. Their series is the largest ever reported. They concluded that tracheotomy plus use of oxygen or air under positive pressure saved at least half of the patients who previously died of anoxia, atelectasis, pulmonary edema or pneumonia.

Sjoberg[23] (Stockholm) in 1950 described 14 bulbar poliomyelitis cases with only 2 fatalities. Sjoberg's paper is most illuminating. Among other things he advances the concept that airway obstruction may "be caused by paralysis of the anterior neck muscles as well as of the pharyngeal constrictors. There results a contracture or tonus excess in the antagonists, i.e., in the remaining, non-paralyzed muscles, which normally maintain the larynx in position. . . . The result is that the larynx is pulled upward and backward, thus blocking the air passage to the trachea." A notch is formed above the hyoid bone as the larynx is pulled into this malposition. Sjoberg has photographs illustrating this.

Sjoberg admits the possibility of fluid obstruction in the airway but thinks mechanical obstruction is more common than is generally recognized. But he believes tracheotomy to be useful for relief of both types of obstruction by providing ingress for air and for aspirating devices to remove secretions.

Mitchell and Hill[27] (Des Moines, Iowa) in 1950 discussed 39 cases of bulbar poliomyelitis seen during 1949. They did tracheotomies on ten and four died. Mitchell and Hill said that "it was our impression that the six who lived did so because of tracheotomy."

Since the last report in 1947[24] 169 cases of bulbar poliomyelitis in adults and children have been encountered at the University of Minnesota. 56 have had tracheotomies; of these 28 died while 53

of the entire 169 died. This is not an impressive survival rate, but this small group has no statistical significance. One must judge each case by itself. It seemed to the physicians in charge of these patients that tracheotomy had contributed materially to the survival of some patients. In reviewing the records of these patients we realized again that waiting for an episode of severe respiratory obstruction before carrying out tracheotomy, particularly in children, in great part defeated the purpose of the tracheotomy. The purpose of tracheotomy is to prevent obstruction, and not primarily to overcome it after it has occurred.

SUMMARY AND COMMENT

In 1947 a large poliomyelitis epidemic was reported from Minneapolis.[24] Since then additional bulbar poliomyelitis cases were encountered. Some of these patients had tracheotomies. The compilation of numerical data follows:

	1946	1947-51
Bulbar Cases	400	169
Tracheotomies	75	56
Lived		104
Tracheotomized and lived	29	25

This is not an impressive survival rate. It seemed to those reviewing these patients' records that delaying tracheotomy until severe respiratory obstruction occurred defeated the purpose of treacheotomy.

Since 1947 about twenty-six papers on the question of tracheotomy in bulbar poliomyelitis have appeared in the world literature. An upsurge in interest has been obvious. This has been rather unjustly termed "a wave of enthusiasm" by several writers. Enthusiasm in this sense has no place in the balanced judgments of physicians. It would be more proper to say that physicians have become aware of the possibility of helping some persons afflicted with a hitherto fatal malady and felt a justifiable satisfaction at the prospect. No paper advocating tracheotomy could be said to be improperly enthusiastic.

All shades of opinion are found in the papers reviewed. The preponderance favors tracheotomy in certain cases of bulbar polio-

myelitis. Secretional obstruction to the airway is the main indication recognized. Pharyngeal paralysis alone is not a proper indication for tracheotomy. There must be inability on the part of the patient to clear his own airway of obstructing secretions. Mechanical obstruction of the pharyngeal airway due to paralysis with resultant distortion of the shape of the pharynx was reported by Sjoberg[23] as an additional reason for performing tracheotomy.

Tracheotomy is regarded as a dangerous and mutilating operation by some authors; therefore they believe it should be withheld and used mainly as a last resort. Others feel that using it early prevents some brain damage by insuring a more adequate oxygen supply during the disease.

The authors of this paper feel that tracheotomy ought to be done early when needed; that it adds very little to the risk when done properly; that the so-called mutilating nature of the procedure has been much exaggerated and is not justified when the operation is correctly carried out; that tracheotomy contributes greatly to the patient's chances when he is unable to clear his own airway of secretion; that administration of humidified oxygen under positive pressure through the tracheotomy tube[14, 28] is a most important form of adjuvant therapy; that criteria for tracheotomy cannot be hard and fast, but that each case is a law unto itself; that tracheotomy should not be done unless other methods of emptying the patient's airway of obstructing secretions have failed to keep the airway clear (pharyngeal aspiration, bronchoscopy, postural drainage); that tracheotomy has a limited but important place in the therapy of bulbar poliomyelitis, and that for the patient who needs it, it may be lifesaving.

Medical Arts Bldg.

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XLIII

TRACHEOSTOMY IN BOTULISM AND RESIDUAL POLIOMYELITIS

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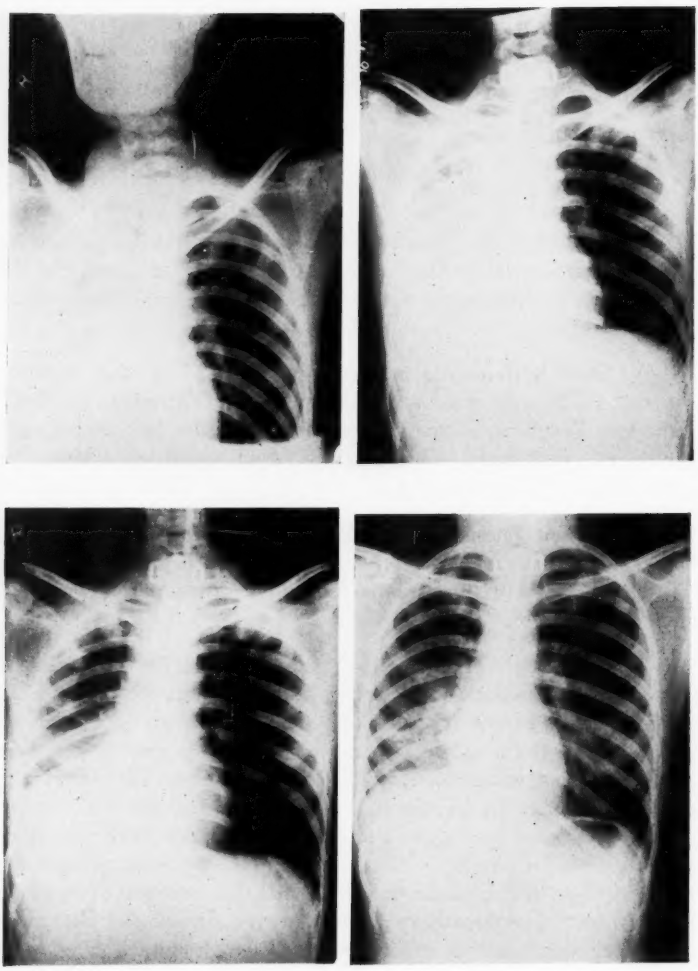
In May, 1948, I reported three cases of botulism before the New York Laryngological Society; two of the patients died and the third on whom a tracheostomy was performed survived. These reports are not published.

In 1949 Boffenkamp and Priest published in the Annals of Otology, Rhinology and Laryngology, an excellent paper on Tracheostomy in Botulism, as the first case in literature in which treacheostomy was performed. The case that I am reporting I believe will be the second to be recorded.

This paper reports three cases of botulism, all in one family, who, after the ingestion of tainted home-canned peppers, developed the disease. Two of the patients died as the result, and one on whom a tracheostomy was performed survived.

Botulism has been recognized since 1820. The toxins liberated by bacillus botulinus acts peripherally on the nervous system. All of these cases ran the true clinical course of the disease, namely, all had partaken of the same tainted home-canned peppers. The symptoms developed within twenty-four hours. They all had vomiting and nausea, dimness of vision, followed by diplopia and dizziness. This was followed by fatigue and extreme muscular weakness, marked dysphagia and dyspnea. Irritability of the patients resulted from their inability to clear their throat of the htick mucous, or to swallow their saliva. The breathing became very difficult and the patients grew very apprehensive, giving the picture of one fighting for air. Bronchopneumonia resulted from the aspiration of pharyngeal secretions, and death was due to respiratory failure. Two of the patients died on the seventh day.

The similarity of botulism and bulbar poliomyelitis is striking.



CASE OF BOTULISM

Fig. 1.—Roengenogram showing drowned lung, 3-2-48, 5 days after admission.

Fig. 2.—Roentgenogram showing beginning clearing after bronchoscopy and tracheotomy, 3-10-48, 8 days later.

Fig. 3.—Roentgenogram showing tracheotomy tube in position and right diaphragm elevated, lung clearing, 3-22-48, 12 days later.

Fig. 4.—Roentgenogram showing considerable clearing of lung, 4-5-48, 14 days later.

REPORT OF CASES

CASE 1.—S. P., white male, aged 52 years, was admitted to the Essex County Isolation Hospital February 26, 1948, with the history of having been ill for five days previously, with acute paralysis and blindness, followed by diplopia. The patient still had diplopia for vision of about ten feet. This was soon followed by difficulty in swallowing. The day following the onset of his illness the patient was admitted to the Mountainside Hospital complaining of pain in his throat. A diagnosis of acute poliomyelitis was made, and he was then transferred to Essex County Isolation Hospital.

On admittance to this hospital the patient was found to be acutely ill and on examination his condition was as follows:

Head: no gross pathology was noted.

Eyes, Ears, Nose and Throat: the pupils are somewhat irregular but equal. They respond to light; accommodation is questionable. He has weakness of both eyes in the lateral motion. There are dried secretions on the palate and pharynx. The uvula is in the midline. There is partial paralysis of the palate and he cannot extend the tongue.

Neck: no weakness of the sternomastoid muscle. No masses in the neck.

Chest: The heart is normal and the lungs are clear.

Abdomen: is soft, no masses. The kidney, liver and spleen not palpable.

Extremities: the reflexes are equal and physiologic, no Babinski, no Kernig, and the skin is clear.

Diagnosis: Food intoxication, Trichinosis or Botulism.

Two days later the Board of Health reported that canned peppers, prepared at home, was the source of the infection.

The prognosis of the patient became progressively worse; he had several episodes of respiratory difficulty due to mucous plugs. On February 28th at 10:50 a.m. the patient had acute respiratory distress, he became cyanotic, thrashed around violently in bed for about 30 seconds and expired; resuscitation was unsuccessful.

Clinical Course: On admission the patient's face was flushed; the pulse of good quality, and regular. His throat was very painful and he was unable to swallow. His mouth was dry and he was unable to take water by mouth. He was very lethargic but spoke coherently. His temperature on admission was 99 and it did not rise until the day he expired when it reached 100.4. Respiration was 20 to 30 and pulse 80 to 90. Botulinus antitoxin, thirty thousand units in 1000 cc of 5% glucose, was given intravenously. Continued suction was applied to the pharynx, and 200,000 units of penicillin was given. The patient's swallowing became progressively more difficult. He had difficulty in speaking, became very lethargic and was unable to cough up the mucus. The following day the respiration became labored, his face was flushed and he was unable to speak or swallow. He became cyanotic, his pulse was weak, his respiration very labored; he was restless, the pulse was thready, and he expired two days after admission to the hospital, and five days after the ingestion of the tainted peppers.

Laboratory Report: Spinal puncture crystal clear. No cell count. Total protein 29 mgs per 100 cc. Sugar 50 mgs per 100 cc. Negative culture. Hemo-

globin 87%; Leucocytes 7,500; Polyneuclears 71%; Lymphocytes 24%; Monocytes 2% Basophiles. Plasma cells 1; Band forms 1; No shift to the left. The urinalysis: acid 1070, albumin and sugar negative. Acetone 3 plus; microscopically negative.

CASE 2.—A white male, 61 years of age was admitted to the Essex County Isolation Hospital on February 26, 1948 with the diagnosis of Acute Poliomyelitis, and with a history of having been ill since Saturday, February 21st. This patient was apparently the first of the three to become ill. It was difficult to get an accurate history from the patient. He complained of a sore throat and headache, had difficulty in swallowing and had no diplopia.

Physical Examination: A 61 year old white male, who appears moderately ill.

Head: no gross pathology noted.

Eye, Ear, Nose and Throat: pupils are round but unequal. The left responds to light; the right is sluggish. Both pupils appear steamy. There is ptosis of the left lid. The tongue is extended in the midline. The uvula is in the midline. There is no marked paralysis of the palate. The patient can take small amounts of fluid slowly.

Neck: no weakness of the sternomastoid muscle. No masses in the neck.

Chest: The heart is somewhat enlarged; no thrills. Has systolic murmur. The lungs are clear.

Abdomen: soft, no masses; kidney, liver and spleen not palpable.

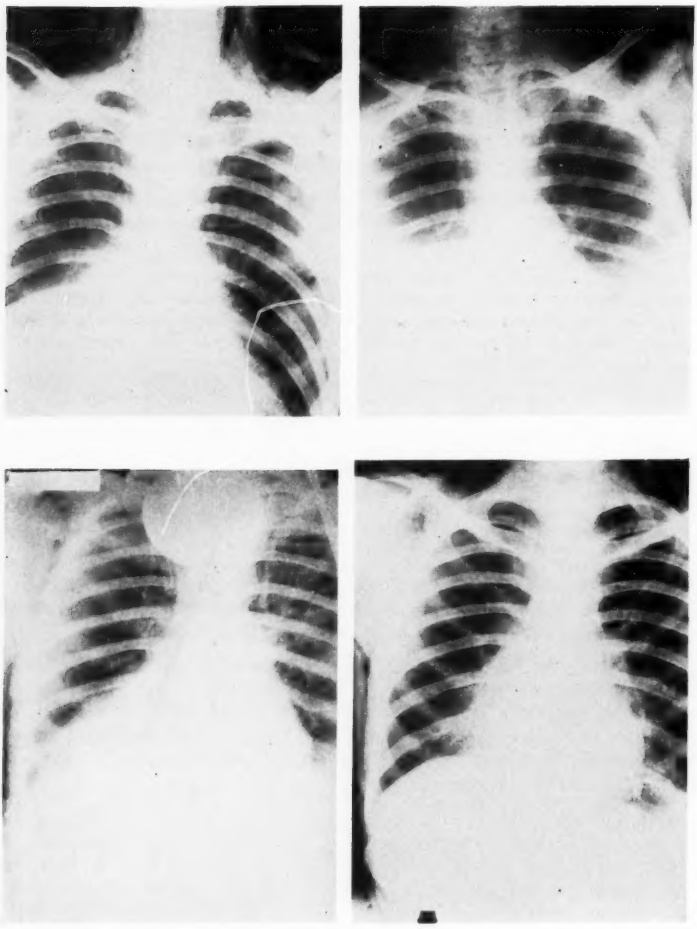
Extremities: reflexes physiologic and equal.

On February 28th the patient was becoming progressively worse. The respirations were difficult and he became weaker. It was impossible to keep the patient in the postural drainage position; his condition was steadily becoming worse with cyanotic shallow respirations and he expired at 4:50 p.m.

Clinical Course: On admission the patient was apparently acutely ill; his face was flushed; the pulse quality good and respirations easy. His throat was very painful and thick tenacious mucus was suctioned from the pharynx. He was unable to swallow. His voice was very husky and he coughed frequently. He was given 5% glucose in 1000 cc saline intravenously.

Constant suction was applied to the pharynx. The patient became very lethargic and was unable to take liquids. His face was flushed, and the skin warm and dry and he was extremely restless. The following day respirations were difficult and labored; he was unable to swallow and artificial feedings were necessary; suction was used frequently. Respiration finally became more labored, he was perspiring freely, his face was flushed and he was not cooperative; he thrashed about and voided involuntarily. On February 28th he was very cyanotic, his respirations were labored and shallow and he did not respond to voice. His color was poor, and he expired two days after admission to the hospital.

The temperature of 101.6 dropped to 99 on Feb. 27th the day after admission, it then elevated to 100.6 and dropped to 99 just before he expired. Respirations 20 to 40 and pulse 100 to 130. Penicillin 200,000 units was given, plus thirty thousand units of antitoxin in glucose intravenously.



CASE OF RESIDUAL POLIOMYELITIS

Fig. 5.—Roentgenogram showing emphysema in the tissues and beginning drown lung, 3-9-49. Picture taken on admission.

Fig. 6.—Roentgenogram showing increased emphysema and drown lung, 3-10-49, next day.

Fig. 7.—Roentgenogram after mediastinotomy and with Wangenstein apparatus applied, 3-12-49, 2 days later.

Fig. 8.—Roentgenogram after tracheostomy showing clearing of lung, 3-18-49, 6 days later.

Laboratory Report: Spinal fluid normal. Urine negative for any pathology, Blood hemoglobin 81%; Leucocytes 8,550; Polyneuclears 80%; Lymphocytes 14%; Monocytes 4%. Plasma cell 2; Band forms 10; Segmented forms 70; Neuclear forms 7; shift to the left.

CASE 3.—A white female, aged 25 years, was admitted to the Essex County Isolation Hospital on February 26, 1948. The patient was taken ill while dancing five days previously when she suddenly became dizzy. The following day she began to have difficulty in swallowing which progressed rapidly. She had attacks of nausea, vomiting and regurgitating through the nostrils. The patient's father and uncle had the same condition.

Physical Examination: A poorly developed female appearing acutely ill.

Head: No gross pathology noted.

Eyes, Ear, Nose and Throat: The pupils are round and equal and respond to light and accommodation. The external ocular muscles are normal. There is no facial paralysis. The tongue deviates from the midline. The uvula is in the midline. Pharynx is not congested.

Neck: no masses. No weakness of the sternomastoid muscle and no rigidity.

Chest: The heart is normal. Lungs are clear except at the right base posteriorally where an occasional wheez is heard.

Abdomen: Abdominal reflexes are present; no masses. Kidney, liver and spleen are not palpable.

Extremities: The reflexes are equal and physiologic.

Clinical Course: On admission the patient appeared rather ill; pulse was very rapid, of good quality; respirations were very shallow and appeared labored. The patient had a frequent short unproductive cough. The eyes were very puffy. A spinal puncture was done. The patient could not take liquids, and had some difficulty in breathing. She was restless and gasping for breath. She had a constant harsh cough and tried to clear her throat. 200,000 units of penicillin was given also 1000 cc of 5% glucose in saline was given intravenously. The next day the patient appeared a little better. Later in the morning she became restless and had more trouble swallowing; it was impossible to get rid of the thick pharyngeal secretion, wherefore she was placed in a postural drainage position. On February 28 the Board of Health reported the illness as due to ingestion of tainted home-canned peppers. 200,000 units of penicillin and 30,000 units of antitoxin in 1000 cc of 5% glucose were given intravenously. The patient was still complaining of difficulty in swallowing and speaking, and was having some abdominal pains. The respirations were labored and was speaking only in a whisper. There was incontinence of urine. On March 1, 1948 there did not seem to be any change in the patient's condition; the temperature had been rising for the past three days. Examination of the chest showed dullness in the lower half of the chest, on the right, posteriorly. The patient was weak and exhausted and breathing was still difficult. She was going progressively down-hill.

X-rays showed clouding of the right chest in the lower half and a shift of the mediastinum. The patient became cyanotic and the breathing was more labored. The right side of her face was swollen and the right eye edematous and almost closed.

On March 4, 1948, the pulse was rapid, the respirations shallow, the tongue thick and she was having marked difficulty in breathing.

At this time I suggested tracheostomy and bronchoscopy. A bronchoscopy was done first and considerable amount of secretion was aspirated from the right side; this was followed by a tracheostomy.

On March 5th the patient appeared slightly improved and the tube feeding was continued. On March 7th she was considerably improved but still unable to swallow. She continued to improve and the swallowing also slowly improved. On April 7th she was again swallowing normally and the action of the cords was normal. The tracheostomy tube was removed and the patient was discharged from the hospital on April 21, 1948.

Laboratory Report: February 26, 1948: the spinal fluid crystal clear; cell count 0. Total protein 29 mgs. per 100 cc. Sugar 50 mgs per 100 cc. Culture negative. On February 27th the blood hemoglobin was 84%; Leucocytes 14,800; Polyneuclears 87%; Lymphocytes 4%; Monocytes 8%; nuclear index 4, with marked shift to the left. The urinalysis: showed acetone and albumin for the first week, then became normal. The x-rays on March 2nd showed definite atelectasis of the right lung, the mediastinal contents retracted to the right. On March 10th the left lung was clear but patient still had some atelectasis on the right. On March 22nd the right diaphragm was high but smooth; the left showed no abnormality. On April 5th the lung was clearing considerably.

The similarity of symptoms of botulism and bulbar poliomyelitis is manifest, and the performing of a tracheostomy in both has definitely a very beneficial, if not a curable effect.

I shall now very briefly report the case of bulbar poliomyelitis.

D. B., a white male, aged 17 years, on whom I had performed a tracheostomy 8 months previously, was decannulated and discharged from the hospital with a residual paralysis of the left cord and palate. This was in 1948. I did not see him again until March 9, 1949, when he was admitted to the Presbyterian Hospital with a diagnosis of pneumonia. At this time I found not only a drowned lung but also emphysema of the neck and face. X-rays showed a mediastinal emphysema, the result of the patient's attempting to cough up secretions. He was placed in an oxygen tent to ease the breathing. The next day he was very much worse, the emphysema had extended over most of his body and his breathing became very much embarrassed. X-ray showed that the heart had shifted to the opposite side. To provide an exit for the air in his tissues a cervical mediastinotomy was done while the patient was in the oxygen tent. A Wangensteen apparatus was applied to the opposite area for suction. Following this the patient seemed to improve until the third post-operative day when it became necessary to perform a tracheostomy, which was done while the patient was in the oxygen tent. As soon as the trachea was opened he was able to cough up a large amount of secretion through the tracheostomy tube. His condition improved, the emphysema subsided and he was discharged from the hospital on the twenty-fourth day, still wearing the tracheostomy tube.

The interesting points about these two cases are: 1) the inability to clear the larynx of secretion by coughing, and 2) the

ease of clearing the secretion through the tracheostomy tube by coughing.

In the case of botulism the patient had no paralysis of the larynx, whereas in the bulbar poliomyelitis case the patient had a recurrent paralysis on one side, yet the same type of cough was noticed in both cases. What is the innervation to cause this? I have endeavored to find out and the following may have some bearing on the subject.

Sensation is served by the recurrent laryngeal nerve up to the level of the vocal cords, and by the internal branches of the superior laryngeal nerve above this point.[1] The vagus is composed of various types of fibres which includes a large number of splanchnic efferent (parasympathetic), and also many splanchnic afferent fibres. In general the parasympathetic efferent fibers of the vagus both in the thorax and in the abdomen become intimately associated with the sympathetic fibres, and it is impossible by dissection to unravel the two sets. In the respiratory system the vagal fibres induce bronchial constriction. The many splanchnic afferent fibers incorporated in the vagus have a field of distribution, equally wide, from the respiratory tract. The muscular branches supply the trachea, and inferior constrictor muscle of the pharynx, and communicating branches to the inferior cervical ganglion of the sympathetic. The thoracic plexus and the pulmonary plexus, are predominantly vagal parasympathetic. Does the constriction of the inferior constrictor muscle of the pharynx, plus bronchial constriction cause this tremendous explosive cough when the tracheostomy is done?

CONCLUSION

Three cases of botulism are reported. Two of the patients died and the third on whom a tracheostomy was done, in addition to the usual treatment, was the only one who recovered. In view of the similarity of botulism and bulbar poliomyelitis, it is advisable to do a tracheostomy in both conditions in addition to the routine treatment of botulism, when that exists.

SUMMARY

Three cases of botulism, in one of which a tracheostomy was performed are reported; as well as a case of residual bulbar poliomyelitis in which a tracheostomy was done following mediastinal emphysema.

The sudden expulsion of mucus from the trachea after tracheostomy is performed, both in botulism and in bulbar poliomyelitis, suggest further study of the innervation of this area.

In the case of botulism there was no paralysis of the larynx.

In the bulbar poliomyelitis case there was a recurrent paralysis on one side.

The same type of cough was seen in both cases. Why?

224 DELAVAN AVENUE.

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XLIV

BENIGN TUMORS OF THE LARYNX

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AND

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The extremely thorough and valuable work of New and Erich[1] on Benign Tumors of the Larynx serves as a reference in regard to these tumors. This discussion of our own series of benign laryngeal tumors is prepared in a similar manner for statistical purposes. It consists of an analysis of 1197 patients with benign laryngeal growths that have been examined at St. Luke's and The Children's Memorial Hospitals and at the Research and Educational Hospitals of the University of Illinois, Chicago, during the past 15 years.

Following New and Erich's suggestion, the term "benign laryngeal tumor" is used here to include "any abnormal mass of tissue in the larynx—providing that it lacks the infiltrative qualities and the power to metastasize characteristic of a malignant lesion." Not included in this analysis are the inflammatory tumors of tuberculosis and syphilis, although other specific inflammatory tumors are recorded.

ANALYSIS OF CASES

Referral to Table 1 demonstrates that the localized polyps, of which 521 cases were seen, were the commonest of the tumors. Next in order of frequency were the nodules (193 cases), papillomas (115 cases), polypoid degeneration (112 cases), mucous retention cysts (73 cases), hyperkeratosis (59 cases), granulomas (49 cases), leukoplakia (23 cases), pachydermia (16 cases), laryngeal ventricle prolapse (10 cases), laryngocele (7 cases), with hematomas, hemangiomas, chondromas,[2, 3] and other rare tumors listed seen fewer than five times.[4]

The site of origin of the tumors was, in the great majority of cases (approximately 97%), on the true cords themselves. 321 of

TABLE 1.—TYPES OF TUMORS—HISTOLOGIC CLASSIFICATION

	NUMBER	PERCENTAGE
NEOPLASTIC		
Papilloma	115	9.57
Chondroma	2	....
Atypical mesoblastic	1	....
Hemangioma	4	....
Lymphangioma	1	....
Myoblastoma	1	....
Neurofibroma	1	....
Hyperkeratosis	59	4.90
Leukoplakia	23	1.91
NON-NEOPLASTIC		
Scleroma	2	....
Histoplasmosis	1	....
Blastomycosis	1	....
Granuloma (non-specific)	49	4.08
Mucous retention cyst	73	6.07
Polyps—localized	521	43.38
Polypoid degeneration	112	9.32
Nodules	193	16.69
Pachydermia	14	....
Laryngocele	7	....
Amyloid	2	....
Hematoma	5	....
Prolapsed ventricle	10	....
TOTAL	1197	....

the 1197 patients (26.1%), had bilateral lesions. In the remainder of the patients, in whom the lesions were unilateral and originated on one of the true cords rather than in the anterior commissure, or outside the glottis, the point of origin was equally divided between the right and left vocal cords.

The sex distribution is of interest. There were in the whole group of patients 70% males and 30% females. In every category the number of male patients with benign laryngeal tumors far exceeded the number of female patients except in the cases of vocal nodules and of hematomas of the cord edges where females outnumbered males approximately two to one.

CLASSIFICATION

The gross appearance of benign tumors serves as a very useful basis for establishing a classification since the clinical manifestations of these tumors depend more upon this aspect than on their histologic characteristics.[5] For example, many polyps, areas of polypoid degeneration, papillary (not papillomatous) projections from the edge of the vocal cords and areas of diffuse cordal swelling appear as one group of lesions under the microscope. They are, in fact, often simply edematous folds of laryngeal mucosa. Nevertheless, their etiology, symptomatology, gross clinical appearance and even treatment may vary so widely that of necessity the gross clinical features must be taken into consideration in establishing a final classification. The reverse is also true, as New and Erich[1] point out. The clinical appearance of many tumors on the edge of the cords at the junction between the anterior one-third and posterior two-thirds of the cord may be identical, while histologically they may vary considerably.

In this discussion the general classifications of New and Erich will be followed, realizing the advantages as well as the defects of this classification as they indicated. Thus, a differentiation of the lesions is dependent upon the site of origin and the extent of involvement, i.e., whether the lesion originated in the anterior commissure, the junction of the anterior and middle thirds of the cord, or the vocal process of the arytenoid; and whether it originated on the phonating edge of the cord, on its superior surface or subglottically, or upon the epiglottis or aryepiglottic folds. A record of the extent of involvement is likewise of significance since identical histologic tumors may be pedunculated, as discrete polyps, or sessile, as diffuse polypoid

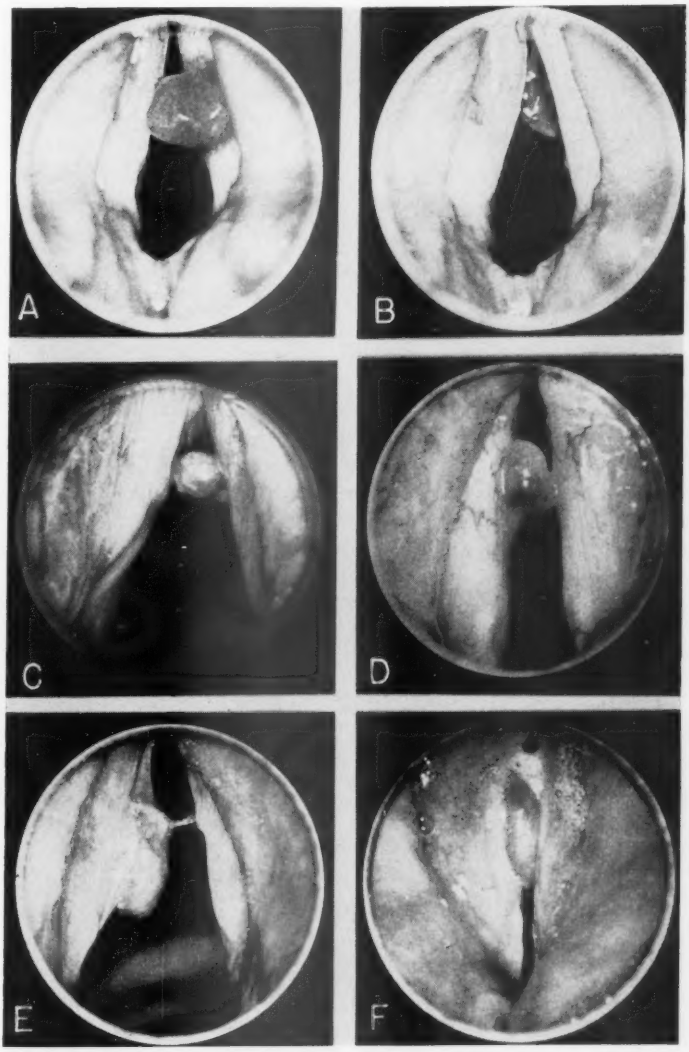

Fig. 1.—Pedunculated polyps of the larynx.
A. Supraglottic position of pedunculated polyp during phonation.
B. Same case during inspiration.
C. Similar lesions arising slightly subglotically.
D. Polyp attached to the phonating edge of the left cord.
E and *F*. Vascular polyp on left cord during inspiration and phonation.

degeneration extending along an entire cord; and the involvement may be unilateral or bilateral.

The benign tumors of the larynx are divided into the benign neoplastic tumors and non-neoplastic tumors. The neoplastic tumors are further subdivided into tumors of epithelial origin, those of connective tissue origin and cysts. Certain variations in the classification will be made, however, notably in considering the hyperkeratotic lesions as benign neoplastic tumors rather than as non-neoplastic lesions.

DISCUSSION

Polyps. By far the largest group of cases were the localized polyps of the vocal cord.[6] In over 500 of the 521 cases, the polyps were attached to the phonating edge of the cord at the junction between the anterior one-third and posterior two-thirds of the cord. In only three cases did the polyps originate in a position other than the anterior one-half of the cord; one of the three originated in the left ventricle, the other two from the right arytenoid. In 21 patients previous removal of a polyp had been done elsewhere, indicating that a recurrence of these lesions after surgical removal is not unlikely; while actual proof is lacking, it is felt that persistence of faulty speech habits after removal of the polyp may be responsible for its recurrence.

Polypoid Degeneration of the Cord. It was recognized that the histology of the polyps and the so-called polypoid degeneration of the cords is similar but the term polypoid degeneration is used to denote the diffuse swelling of the entire length of one or both cords. There were 112 patients with polypoid degeneration of one or both cords. Only 35 of the 521 cases of pedunuculated polyps were bilateral (7%) while 70 of the 112 patients with polypoid degeneration (62.5%) had bilateral lesions. In 8 cases there was a prolapse of the ventricle, either unilateral or bilateral, in addition to the polypoid degeneration of the cords. In each instance when the polypoid material was removed from the cord, subsequent examination revealed an essentially normal larynx suggesting that the prolapse was the result of the traction due to the weight of the polypoid material and the trauma of phonation. The duration of symptoms of patients in this group was as follows: one to six months, 41; seven months to three years, 38; three to five years, 10; and

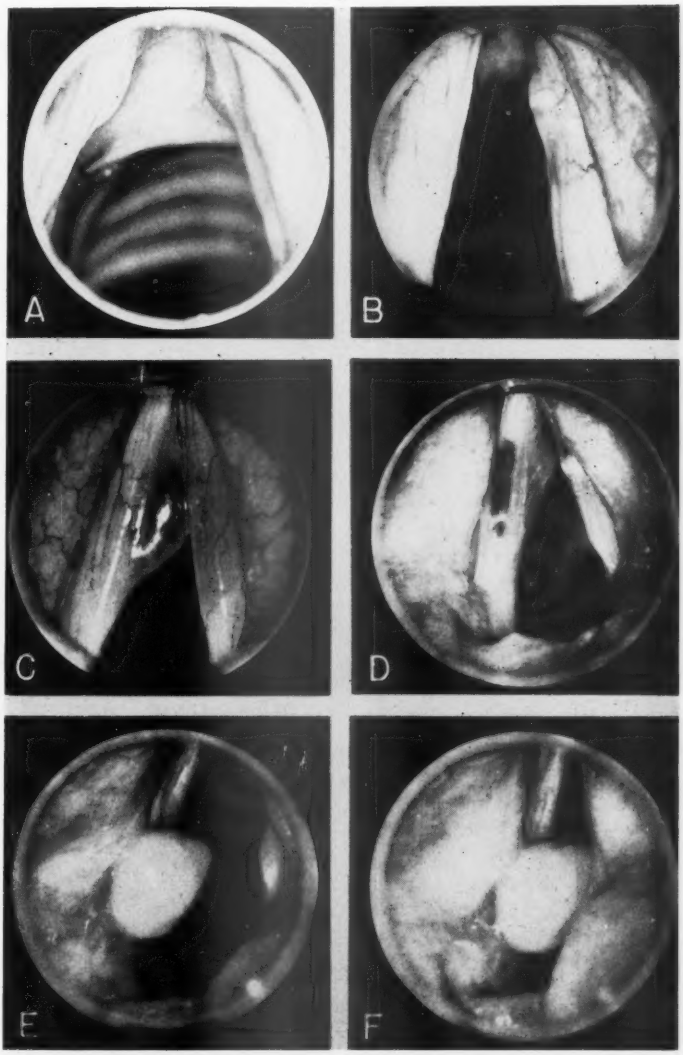

Fig. 2.

A. Bilateral vocal nodules.
B. Cyst of the right vocal cord.
C. Sessile polyp along the anterior and middle one third of the left vocal cord showing the characteristics of polypoid degeneration of the cord.
D. Lesion similar to that of "C" but with hematoma in the body of the cord itself.
E. Nonspecific granuloma of the left false cord associated with contact ulcer.
F. Same lesion during phonation showing manner in which the granuloma prevents approximation of the cords.

over five years, 31. The age incidence of this group increased with each decade; 2 were from eleven to twenty years of age; 8 were from twenty-one to thirty; 18 were from thirty-one to forty; 35 were from forty-one to fifty; 37 were from fifty-one to sixty and 20 were over sixty. In almost all instances, surgical removal was curative and there were no obvious recurrences in any that had been adequately removed. There were two cases of prolapse which were not associated with polypoid degeneration. In these two cases there was no obvious cause and in each instance the prolapse material was removed with forceps.

Vocal Nodules. There were 193 patients with vocal nodules.[7] In 148 of these, the lesions were bilateral while in the remainder the incidence of right or left cord involvement was equal. In all but three cases the lesions were located at approximately the junction of the anterior one-third of the cord with the posterior two-thirds of the cord. This differs with the report of Ash and Schwartz[8] who state that the nodules in the great majority of their cases were found in the anterior one-third of the cord and the anterior commissure. The difference is undoubtedly one of terminology.

Papilloma. 109 of the 115 cases of papilloma of the larynx were previously reviewed,[9] the remaining 6 having been seen since that report. Two of the six additional cases were adults, both male, and the ages of the 4 children were 6 years, 5 years, 3 years and 14 months, three of them males, one female.

Hyperkeratosis and Leukoplakia. A total of 82 patients were seen with hyperkeratosis and leukoplakia. These lesions consist of a marked thickening of the epithelium with hornification; the terms are, in some respects, synonymous. Both types of lesions are considered premalignant. The term leukoplakia is reserved for those in which the stroma shows marked inflammation, but this differential point between the two processes could not be correlated with differences in their gross appearance. The tumors of this group were seen in several gross variations: superficial, gray, granular areas extending along the surfaces of the cords or on the epiglottis, arytenoids or aryepiglottic folds; plaques of grayish-white exudate, verrucous in character and varying in size from small patches to extensive involvement of the whole interior of the larynx; and soft, moist ulcerated areas with granulation tissues reddish in color interspersed with the white exudate from which the lesion derives its

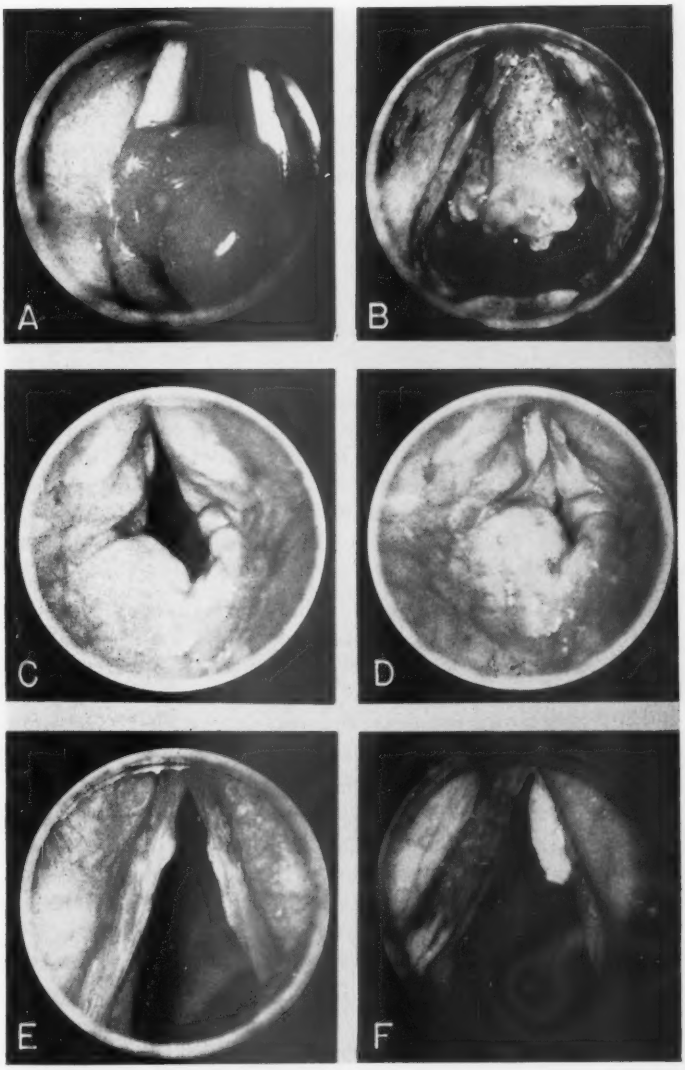

Fig. 3.—*A*. Bilateral granulomas following intratracheal anesthesia.
B. Pedunculated papilloma arising from the anterior commissure.
C. Hyperkeratosis and pachydermia laryngis.
D. Same larynx as "C" during phonation. Note heaping-up of epithelium into heavy folds in the posterior commissure.
E. Diffuse hyperkeratosis of the larynx.
F. Superficial keratotic plaque on the right vocal cord.

name. The latter were most prone to develop malignant changes while the preceding group occasionally underwent malignant changes after years of proliferation of the keratotic tissues. It was a clinical impression that patients with lesions of the first group responded most readily to elimination of local irritation caused by such agents as tobacco, alcohol and industrial fumes. Appropriate voice correction therapy was stressed.

Granulomas. 49 patients had non specific granulomas. 13 of the granulomas were on the vocal process of the right arytenoid, 20 on the left and in 16 cases they were bilateral. 12 of these followed intubation for intratracheal anesthesia, 32[10, 11] were associated with contact ulcers; 5 on the true cords had no apparent etiologic trauma.

Cysts. 73 cases of cysts of the larynx are recorded. 38 of these were on the vocal cords and 35 in the vallecula, on the aryepiglottic folds, arytenoids or epiglottis. On the cords they were comparable to the chalazion of the eye while in the other areas they appeared as yellow, pedunculated mucus containing masses of varying sizes from 2 to 10 mm in diameter.[12,13] In the vallecula and on the anterior surface of the epiglottis they were usually multiple.

Laryngoceles. Seven patients with laryngoceles are included in this series. Two were seen in infants and have been previously reported.[14] One was an incidental bilateral finding in a laryngectomy specimen of a patient with carcinoma of the larynx. Two were mucous-filled sacs, one unilateral and one bilateral, that were removed surgically and the other two were large bilateral air-filled tumors in patients who refused surgical excision.

Hemangioma and lymphangioma. Four cases of hemangioma and one of lymphangioma of the larynx are recorded; all five patients were female. There were two capillary hemangiomas, one on the left aryepiglottic fold and one on the right cord. The first patient was 39 years of age and symptoms of hoarseness had been present 9 years. The second was 38 years of age and had hoarseness and "a lump in the throat" for 2 years. Two were cavernous hemangiomas, one on the left lateral-pharyngeal wall, pyriform sinus, aryepiglottic fold and extending across the left false and true cord. The patient was 21 years of age and had had symptoms since birth, almost exsanguinating during a tonsillectomy at 5 years of age. The lesion has been injected with sodium morrhuate. The second involved the epiglottis and larynx of an 8 month old infant

TABLE 2.—DURATION OF SYMPTOMS—BENIGN TUMORS OF THE LARYNX (EXCLUDING PAPILLOMAS)

DURATION	NUMBER	PERCENTAGE
1 - 6 months	446	41.03
7 months - 3 years	430	39.55
3 - 5 years	70	6.44
Over 5 years	125	11.49
Undetermined	16	1.47
	Total 1087	Total 99.98

with symptoms of stridor and dyspnea since birth finally necessitating a tracheotomy.[15] The infant with a lymphangioma was 3 months of age and the lesion was in the subglottic portion of the larynx on the left side. She too had had symptoms of stridor and dyspnea since birth requiring tracheotomy.

Specific inflammatory tumors other than those of tuberculosis and syphilis consisted of two patients with blastomycosis, two with the laryngeal tumors of rhinoscleroma and one whose tumor proved to be a histoplasmosis.[16]

Pachydermia: The cases of pachydermia hardly deserve to be mentioned under tumors of the larynx since the lesion is, in reality, a thickening of the squamous epithelium in the posterior commissure. There were 13 cases of pachydermia, bilateral and involving the posterior commissure except in one patient in whom only the left cord was involved. All of these patients had symptoms of hoarseness longer than six months and the majority had symptoms for over five years. The lesions were equally distributed between males and females and most common between the ages of 40 to 60 years. The lesion is considered inflammatory and generally due to chronic sinus infection. Aside from removal of the thickened folds of tissue in the posterior commissure which prevented approximation of the cords during phonation, treatment was always directed toward irradication of the primary source of the infection in the sinuses.

THERAPY

In the great majority of cases therapy consisted of cup forceps removal under direct laryngoscopic guidance. The use of local anesthesia in adults[17] rather than general anesthesia was considered to be important in that an evaluation of the condition of the cord edge during both inspiration and phonation is possible in the patient who can respond to the request to say "E" whereas the loose, flaccid cord of the patient under general anesthesia can not be so studied. No cautery was used on the cord edges after removal of the benign polypoid lesions and nodes. Following removal the patient is instructed to remain silent for 10 days, using pencil and paper for communication, avoiding whispering as well as normal speech. Voice correction therapy is considered essential for individuals with nodules and polyps as well as for those with granulomas associated with contact ulcers. The influence of vocal abuse as an etiologic factor in the development of many of the lesions herein described, particularly the polyps and nodules, was apparent in reviewing the records. The number of cheer leaders, trial lawyers, preachers, salesmen and professional singers as well as the "barbershop quartet" type of singer who made up this group was significant.[18] Of significance, too, was the number of women in this group with small children that they felt required constant disciplining. Such harsh, raucous use of the voice, singing or other voice use in the presence of laryngitis seemed of definite etiologic significance.

Therapy of the papillomas included in this series was reported in detail elsewhere. Aureomycin is still considered to produce some effect upon the growth and rate of recurrence and in 3 of the 9 patients in whom it was used no further recurrence has developed. It is conceded, of course, that this may be incidental and that the series is still too small to be of statistical significance..

In patients with hyperkeratosis every effort was made to eliminate local irritation, especially that due to tobacco. The cords were stripped of the exudate if it could be readily removed but this always presents a dilemma in that removal of a piece of tissue sufficiently large to provide the pathologist with an adequate depth for interpretation may necessitate destroying the continuity of the edge of the cord during phonation. Nevertheless, such biopsy may be necessary in recurring keratosis and in patients who have lesions of in-

TABLE 3.—DISTRIBUTION, AGE AND SEX OF INDIVIDUAL CASES—BENIGN TUMORS OF THE LARYNX (NON-NEOPLASTIC)

TUMOR	NUMBER	SITE				AGE				SEX	
		Vocal Cords									
		Right	Left	Bilat.	Other	1-10	11-20	21-50	Over 51	MALE	FEMALE
Polyps	521	239	244	35	1-lt. Ventricle 1-rt. Arytenoid	11	7	389	114	442	79
**Polypoid degeneration	120	25	25	70	.....	None	2	61	57	75	45
Cysts	73	21	16	1	3-Arytenoid 4-Aryepig. fold 1-False cord 24-Vallecula 3-Epiglottis	9	6	41	17	46	27
Nodules	193	18	27	148	.....	53	26	104	10	63	130
Granuloma	49	13	20	16	.....	None	None	29	20	36	13
Hyperkeratosis	59	18	15	25	1-Post. Commissure	None	None	25	34	51	8
Leukoplakia	23	9	4	10	.....	None	None	13	10	19	4
Hematoma	5	4	1	....	.....	None	None	3	2	1	4
Pachydermia	14	....	1	13	.....	None	None	7	7	7	7
Laryngocele	7	3	2	2	.....	2	None	4	1	7	....

**Including 8 cases in which prolapse was associated with polypoid degeneration.

creasing histologic activity. Thyrotomy with removal of one cord was done in two patients because of the activity of the lesion. In one patient a frequently recurring, extensive keratosis involving the entire glottis eventually developed the histologic characteristics of a true malignancy after six years, simulating the disease described in the classical report of McEnty.[19]

SUMMARY

1. A statistical analysis of a series of 1197 patients with benign tumors of the larynx is presented.

2. Classification must be made on the gross, clinical manifestations as well as on the histology.

3. 97% of the lesions were on the true cords, 26% of them, bilateral. Males far exceded females except in vocal nodules and hematomas where the 2-1 ratio reversed itself.

4. Therapy in the great majority of cases consisted of forceps removal under local anesthesia. In bilateral lesions involving the anterior commissure, only one side was removed at a time. The external surgical approach was used in extensive lesions.

5. The importance of voice correction therapy stressed.

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XLV

LARYNGOCELE

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A visitor touring the streets of Cairo in 1829 might have been startled to hear periodically ringing out from the minarets above the city a stentorian voice calling upon the faithful of Mohammed to pause for a moment of prayer. His surprise, however, could scarcely have matched that of Larrey,[1] a Napoleonic surgeon whose curiosity led him to examine these human loud speakers and thus to discover that many of them exhibited a peculiar, compressible, pouch-like swelling at the side of the neck. Such laxity of supporting tissues in the neck led sometimes to the need of a supporting collar and if despite such reenforcement the broadcasters of that day were unable to carry on, it is recorded that they were then relegated to the more menial task of tending the fish ponds of the mosques.

Designating this phenomenon by the French equivalent of "laryngocele," Larrey, by virtue of this observation, became the first clinician, with the possible exception of the omniscient Galen, to call attention to this unusual condition and so to find himself heading the biblographical list of every subsequent writer on the subject. Larrey would indeed have been surprised and perhaps annoyed could he have foreseen that 80 years later von Hippel,[2] the author of by far the most comprehensive monograph on the subject of laryngocele, was to declare that the swellings observed by Larrey in the necks of the minaret callers were not true laryngoceles but were in fact either markedly dilated external jugular veins or cystic goitres, induced only indirectly by the strenuous demands made upon their voice. Otherwise, argued von Hippel, every Wagnerian opera singer or itinerant fish peddler would present the same phenomenon, which actually is of great clinical rarity.

Such disagreement as to the exact nature of a true laryngocele and as to its anatomy and its etiology has persisted to the present day and the resultant confusion and lack of uniformity of definition account for the great variation in the number of reported cases.

While there are many excellent surveys of the subject (6-19) it is the object of this paper, in adding a further case report, somewhat to rearrange the many strands in this tangled skein in the hope thereby of achieving a clearer understanding of the essential anatomical and clinical elements which go to make up what can justifiably be called a true laryngocele.

The ventricle of the larynx was first described anatomically by Morgangi in 1741 and it is after him that the structure is named. The picture seen in most text-book cross sections of the larynx shows the ventricle as a thin half crescent shaped slit between the true and the false vocal cords. Actually it is a horizontal recess of which the ventricular band or false cord forms the upper wall and the lateral portion of the true cord, the floor, while fibres of the thyro-arytenoideus muscle and thyroid cartilage form the lateral wall. Connecting with this ventricular space and entering its anterior third is a pyramidal shaped extension known as the laryngeal saccule, a sort of diverticulum or herniation of the mucous membrane, the apex of which rises to a position between the false cord and the ala of the thyroid cartilage, at times reaching almost to the level of the base of the epiglottis and tending to deviate from the main axis of the saccule to produce the so-called phrygean cap. The painstaking dissections of Hilton,[3] (Figs. 1 and 2) give a clearer understanding of these anatomical relationships and show how inadequate is any simple cross section of the larynx in affording an accurate understanding of them.

Practically all authors consider the saccule as an atavistic analogue of the air sacs seen normally in monkeys and which extend into the neck and even down under the pectoral muscles to provide, in the process of rebreathing, a more effective respiratory apparatus in these animals. The close similarity between such air sacs and the dilatation of the ventricle understood by the term laryngocele, clearly indicates that a definite evolutionary degeneration has taken place.

Histologically the saccule is lined with a mucous secreting membrane covered with ciliated columnar epithelium and containing as many as 60 to 70 glands. Beneath the mucosa one finds histological characteristics which resemble adenoid tissue and lymphatic elements which have led to the designation of "laryngeal tonsil," the only such structure not directly exposed to the surface of the mucosa. The function of these glands is the provision of lubrication to the

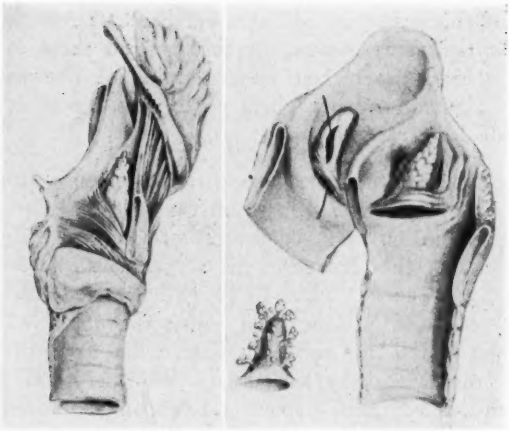

Fig. 1.—Dissection with removal of the right thyroid cartilage, exposing the right saccule as seen from its outer aspect. (After Hilton)

Fig. 2.—Dissection showing the right saccule from the medial side as it lies just above the aperture of the ventricle. Seen with a bristle-passing thru it is the left saccule, illustrating its connection with the ventricular orifice. The small insert shows the tiny grape like prolongations of the mucosal surface. (After Hilton)

vocal cord surfaces. The painstaking dissections of Hilton have shown that the saccule is not a single cavity but like the bays and inlets of a river bed contains branches and pockets (Fig. 2 insert) leading off from the main cavity. Surrounding muscular compression is capable of altering the form and capacity of this cavity by either distending or collapsing it.

In his original description of the laryngeal saccule Morgangi noted great variations in its size, thus leaving open to debate at what point such variations reach a degree warranting the designation laryngocele. To establish the latter, in von Hippel's opinion, there must exist a congenitally abnormal development of the saccule whereby instead of growing parallel to the thyroid cartilage in a cephalad direction it pushes ahead transversely with its peak pointed toward the wing of the thyroid cartilage and its base medially toward the vocal cords. It is therefore this congenital origin, on which may be superimposed contributory factors, which is, according to von Hippel,

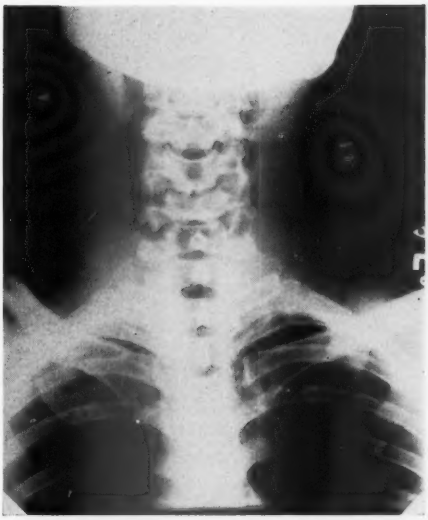

Fig. 3.—Roentgenogram of neck, seen from behind, showing the air containing sac of the left external laryngocele.

the hall mark of a true laryngocele. Not all trumpet players or glass blowers manifest this disorder but such occupation brings to light the congenital predisposition which might otherwise have never became manifest. Such strenuous expiratory effort closes the false cords and together with the sphincteric action of the muscles surrounding the upper aperture of the larynx (thyro-arytenoid, thyro-epiglottic and aryeglottic) prevents momentarily the escape of air. This action puts greatly increased pressure on the saccule which if congenitally weak, tends toward dilatation and further and further herniation.

Acquired interference with the normal exit of air from the ventricle, of varied etiology, may produce a secondary and mechanical herniation of the saccule but such ventricular obstruction is not seen and is not an essential factor in true congenital laryngocele. With characteristic Teutonic thoroughness von Hippel applies to this acquired type of saccular dilatation the formidable term, "dilitatio appendicis ventriculi Morgangni symptomatica."

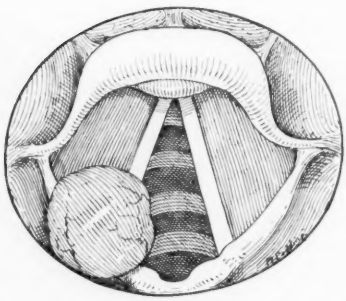

Fig. 4.—Right internal laryngocele (after Jackson and Jackson).

Practically all authors recognize three types of true laryngocele: 1, a purely external type; 2, a purely internal type; 3, a combination of these two. By far the most common clinically is the purely external type where the prolongation of the saccule has forced its way under the aggravation of some form of forceful expiratory glottic closure, along the inner surface of the ala of the thyroid cartilage and through the thyro-hyoid membrane to appear as an air containing, tympanitic swelling, beneath the soft tissues of the neck at about the level of the under surface of the hyoid bone. Such a swelling to qualify as a true laryngocele, in addition to being easily reducible by manual compression must yield air on needle aspiration and exhibit spontaneous appearance whenever the patient achieves forced expiration with a closed glottis. With modern x-ray technique an external laryngocele can be readily demonstrated in the soft tissues of the neck (Fig. 3). The condition is much more common in men, is unaccompanied by any change in voice or in the mirror appearance of the larynx and forms the subject of the majority of all clinical and operative reports dealing with laryngocele.

In the purely internal form of laryngocele a protruding swelling is seen covering the true cord, pushing the false cord forward and sometimes extending across the midline to overhang the true cord on the opposite side (Fig. 4). The volume of this swelling may change with alternating phases of respiration, a most important diagnostic sign. The quality of the voice is always profoundly affected and respiratory obstruction of varying severity may be present.

The combination of both an internal and an external laryngocele would present a summation of the clinical features just described, an example of which is embodied in the present report. Despite opinions to the contrary each of these three types has been clearly and independently described as a clinical entity.

In attempting to arrive at a clinical diagnosis of true laryngocele the chief source of error clearly centers around the purely internal form and its possible confusion with other forms of intralaryngeal pathology which may superficially resemble it. Foremost among these is an eversion or prolapse of the laryngeal ventricle, the purely laryngoscopic features of which may easily lead to confusion with the laryngocele and so afford an explanation for the great variation in the number of reported cases as well as for the frequent diagnostic disagreement even among eminent laryngologists. It was during a somewhat heated argument on this subject that Sir Sinclair Thomson and Mr. Dan McKenzie are said to have almost come to blows. By far the most comprehensive consideration of eversion and prolapse comes to us from Moore[4] who exhaustively summarized 85 cases. A true prolapse originates as an inflammatory edema or hypertrophy of the ventricular walls with resultant protrusion of the mucosa into the laryngeal lumen. It is a condition secondary to trauma, to traction from an adjacent cyst or to a tumor and its diagnostic characteristic is its replaceability within the ventricular lumen by simple pressure with a probe. If sufficiently extensive eversion of the ventricle may be accompanied by similar prolapse of the saccule, a condition which most nearly simulates a true internal laryngocele. The latter however cannot be replaced by probal pressure, is unaccompanied by adjacent laryngeal pathology and is unique in the changes in its size induced by forceful coughing or expiratory effort. Where there is present an accompanying external swelling in the neck, any internal swelling is almost certain to be due to an internal laryngocele and changes in the size of the latter on pressure over the external swelling exclude all doubt as to the diagnosis. Moore summarizes this classification as follows:

Pneumatocele
- a. Laryngocele (congenital)
- b. Hernia (acquired)

Eversion of the Ventricle.
- (a) with eversion of the Saccule.
- (b) without eversion of the Saccule.

Fig. 5.—Sketch showing the operative field developed to expose the external sac.

Pneumatocele differs from the true eversion of the saccule in that the former fills with air on phonation and does not recede into the ventricle.

Both true internal laryngocele and eversion or prolapse of the ventricle and saccule must be further differentiated from simple tumors and cysts of the larynx. Since hoarseness and some degree of respiratory embarrassment are characteristic of all these conditions a most careful diagnostic laryngoscopy is required to make a distinction between them. The swelling associated with an internal laryngocele appears characteristically either at the level of or above the false cord in contradistinction to that of a prolapsed ventricle or saccule which presents itself directly in the ventricular orifice.

The surgical management of a true laryngocele is naturally dependent on whether it is of the internal or external variety. In the case of the latter there is almost complete uniformity of opinion as to the most advisable procedure and its technique of execution. An incision is made through the skin and superficial fascia and platysma muscle at a level just inferior to the hyoid bone and just above the superior border of the thyroid cartilage. Blunt dissection at this point will reveal the outer wall (Fig. 5) of the air-containing sac, further definition of which will expose the narrow neck or pedicle by which the sac is attached to its origin in the ventricle and which pierces the thyro-hyoid membrane. This pedicle can be easily surrounded by a ligature, the sac amputated and the stump, after fix-

ation, allowed to drop behind the thyro-hyoid membrane, after which the overlying neck muscles are approximated and the superficial tissues closed over them in layers.

Despite the simplicity of this surgical procedure and the unanimity of complaints in all patients harboring an external laryngocele, it is not unusual to find expression of the opinion by outstanding laryngologists that failing any respiratory embarrassment an external laryngocele requires no surgical intervention.

The problem involved in the eradication of an internal laryngocele is not so simple. It is common experience among laryngologists that such conservative measures as aspiration, incision and drainage, or piece-meal removal of the walls of the sac tend not only to fail of complete cure but to run grave risk of causing permanent damage to the voice. There remains therefore either an external approach through the wing of the thyroid cartilage or as in the case to be presented, removal of the sac by way of a conventional laryngofissure operation. Only rarely in the event of the occurrence of a combined external and internal laryngocele will the latter disappear after extirpation of the external sac and it will therefore usually be necessary to carry out a two stage procedure for such a double lesion, the rarity of which I believe justifies the following report.

REPORT OF A CASE

J. P., a 40 year old single painter was found one day in November 1946 sitting on the doorstep of a physician, obviously suffering from some sort of upper respiratory obstruction. During the previous four months he had noted some soreness in his throat and the appearance of a peculiar mass on the left side of his neck. Because of his dyspnea the patient was immediately hospitalized but before any laryngoscopic studies or examination could be made something ruptured inside the throat with immediate relief to the obstruction and disappearance of the swelling in the side of the neck.

The patient was discharged from the hospital and remained asymptomatic for three months at the end of which time there was a recurrence of the original signs and symptoms for which on February 26, 1947, he was admitted to the Cushing Veterans Hospital where direct laryngoscopy showed a mass on the left side of the larynx at the level of the ary-epiglottic fold. Puncture into this mass apparently released air and at the same time resulted in a second

disappearance of the swelling in the left side of the neck. The latter however reappeared in a few days at which time it presented the following characteristics. Projecting antero-laterally at the level of the thyro-hyoid membrane this mass was approximately 4 cm. in diameter, was definitely crepitant, was easily compressible by manual palpation and could be increased in size by the patient's forced expiration with a closed glottis.

Indirect and direct laryngoscopy revealed a bulging mass about two centimeters in diameter on the left side near the base of the epiglottis and extending above the ary-epiglottic fold. It appeared to be filled with air, and pressure on the swelling on the left side of the neck produced obvious increase in the size of the intra-laryngeal mass.

X-ray studies (Fig. 3) of the lateral neck revealed a small demarcated pocket of air projecting laterally on the left side between the top of the larynx and the hyoid bone. Under forced expiration it reached a maximum diameter of two by two and a half centimeters. A biopsy of the wall of the internal mass revealed only chronic inflammation.

On March 17, 1947, an operation was performed in the external swelling. A curved incision was made in the skin at the level of the left superior border of the thyroid cartilage, extending from the sterno-mastoid muscle posteriorly, almost to the median line anteriorly. Superficial fascia and the platysma were divided anteriorly. The superior laryngeal nerve and vessels were exposed and identified and a slightly bulging mass was found anterior to this area which was exposed by blunt dissection, with stripping away of all attached fascia (Fig. 5). This mass was found to be a thin walled sac filled with air which could be expressed from it by very slight pressure but which would be greatly distended by the patient's performing the Valsalva maneuver. This sac was dissected from its surrounding attachments and found to communicate with the interior of the larynx by a narrow neck about 1 cm in diameter which passed through the thryo-hyoid membrane just posterior to the median line and immediately over the upper border of the thyroid cartilage. This communicating neck was severed and the stump sutured by a single layer of interrupted black silk sutures, this layer being then invaginated by a second layer of black silk following which, upon release of traction the stump beneath the thyro-hyoid membrane, fascia,

Fig. 6.—Lining of the External Laryngocele. Stratified squamous epithelium, overlying a fibrous stroma. There is nothing to suggest inflammation or other cellular reaction.

muscle, platysma and superficial fascia were closed by interrupted sutures of black silk which were also used to close the skin.

Pathological examination of the tissue revealed a cyst 2.7 by 1.8 by 0.7 cm (Fig. 6). It possessed a vascular fibrous wall with scattered lymphocytes present. The inner surface was lined with stratified squamous epithelium with an underlying fibrous stroma, which shows no evidence of lymphoid tissue or glandular structures normally present in the wall of the saccule. Presumably the marked distention of the saccular wall had led to the disappearance of these structures. There is here seen also a transition from a ciliated, columnar epithelium to a stratified squamous type. A small cyst in the wall was lined by flattened columnar epithelium.

Patient was discharged on March 29, 1947. At this time the neck incision was well healed. The internal laryngocele remained unchanged and without symptoms but excision was postponed for 4 months. A post-operative x-ray on April 8th showed the external laryngocele no longer present. Four months later there was no change in the internal laryngocele. There was no inflammation and the pa-

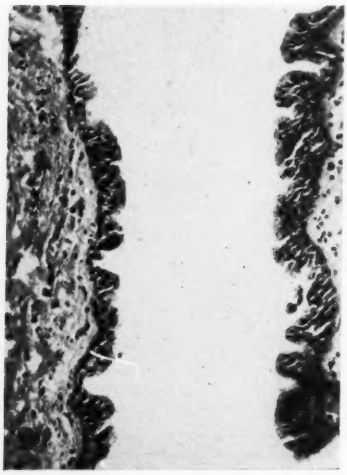

Fig. 7.—Lining of the internal laryngocele. Normal respiratory type of epithelium overlying a fibrous stroma. Slight tendency to papillary formation.

tient aside from hoarseness was asymptomatic. Surgery was postponed in the hope that further operative procedure might not be necessary. Fifteen months after the original operation patient returned with complaints of hoarseness, a sense of fullness in the throat and salivation while talking. Examination showed some enlargement of the internal lesion.

June 4, 1948. Under general anaesthesia an incision was made between the thyroid notch and the episternal notch. The strap muscles were divided and the thyroid isthmus isolated and divided. The wings of the thyroid cartilages were divided with a motor driven saw and separated to expose the internal laryngocele which extended so high upward as to make exposure of its upper border difficult. Submucous dissection with scissors was begun anteriorly at the point of attachment to the left false cord and the laryngocele progressively uncovered and pulled downward from below so as to bring its upper pole within the operative field. Rupture of the sac occurred before its complete dissection was accomplished with escape of about 5 cc of cloudy fluid. Dissection of the sac was continued to its base

which was tied off with catgut and the cyst removed. Because of laceration of the overlying mucosa several raw areas were left on the surface of the false cord. The wings of the thyroid cartilage were approximated and a tracheotomy tube temporarily inserted through the crico-thyroid membrane. The overlying fascia was closed with catgut and the skin with interrupted black silk.

The pathological specimen removed from the interior of the larynx (internal sac) showed (Fig. 7) a normal respiratory type of epithelioma overlying a fibrous stroma. There is a tendency to papillary formation of the surface, closely resembling the normal ventricular mucosa. Except for a transitory hematoma in the superficial wound the patient made an uneventful recovery. The voice showed steady improvement, though still slightly husky and there has since been no recurrence of either the internal nor external laryngocele. The patient has been able to resume his occupation and when last seen was in perfect health.

Taylor[5] in an excellent resume of the subject of laryngocele in 1944 stated that up to the time of his report there had in 66 years of this Society's meetings been only one report on this subject. I have therefore felt all the more justified in bringing it once again to the attention of this meeting.

SUMMARY

True congenital laryngocele is a clinical entity of great rarity. Its confusion with a variety of other laryngeal lesions having somewhat similar clinical manifestations has led to misunderstanding of its true nature, the mechanism of its origin and hence to failure to apply the most effective measures for its eradication.

A case is described illustrative of the combined lesion of an external and internal laryngocele with a description of the surgical measures employed for their eradication.

I am indebted to Dr. Everett Tomb, Chief of the Otolaryngological Department of the Cushing Veterans Administration Hospital, Framingham, Mass., for permission to utilize some of the material incorporated in this case report.

1101 BEACON ST.

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XLVI

WINDOW LARYNGOFISSURE FOR CARCINOMA OF LARYNX

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It is not the object of this paper to discuss the various methods of treatment of early carcinoma of the larynx. It must be said, however, that the surgical removal of the growth has been the only successful method of cure in our experience.

The operation to be shown was first reported in 1948. Since that time, nineteen cases have seemed to meet the requirements for laryngo fissure and have been treated by this method. There has been one known recurrence requiring laryngectomy and two cases have developed masses of granulation tissue which were removed through a direct laryngoscope. As this procedure has been used only a short time (three years) a statistical report is not given. The technical approach to the larynx is shown in the hope that it may be of interest.

Though the physical appearance of a laryngeal growth may simulate a malignancy microscopic examination of tissue removed from a suspicious area is the only sure method of diagnosis. LeJeune[1] has reported a series of cases where the carcinoma was the size of a grain of rice, pea or dimpled match head. These cases have been treated by him by excision and cauterization through the suspension laryngoscope. We rarely see this type of case.

The operation that will be shown is for a larger growth, one that does not extend beyond the true cord and where there is no fixation of the movement of the cord. The main idea of any surgical procedure in cancer is to remove all the growth along with any cells that may have migrated away from the main growth. This calls for a fairly wide excision of the growth along with surrounding tissue which is apparently normal.

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In 1928 Finzi and Harmer[2] recommended a window resection in the lateral wings of the thyroid cartilage for the implantation of radium needles in the treatment of carcinoma of the larynx. Arbuckle[3] also has advocated window resection for x-ray treatment of malignancies of the larynx. By removing a portion of the cartilage they hoped to prevent sloughing and abscess formation associated with destruction of the thyroid cartilage.

A modified window resection has been devised that gives access to the larynx and permits a thorough inspection before removal of the suspected area (Broyles[4]). It gives a dry field for inspecting the interior of the larynx and a wide field for removal of early growths.

If there is a fixation of a vocal cord or an arytenoid cartilage or evidence that the growth extends to the cricothyroid membrane, a more extensive operation is necessary.

This procedure is for small malignant growths confined to the true vocal cords, where there is no fixation of the arytenoid or lagging of the movement of the cord.

(A motion picture of the procedure was shown.)

1100 N. Charles St.

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XLVII

MODERN TRENDS IN OTOLARYNGOLOGY WITH SPECIAL EMPHASIS ON ALLERGY

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Twenty-five years ago otolaryngology was a simple well defined specialty concerned in the main with a limited number of pathological entities, requiring only a few standardized therapeutic procedures.

Infection was credited as being the agent which produced the majority of all ear, nose, and throat symptoms and the recognized treatment in most cases was surgery.

The discovery of the sulfa drugs and the antibiotics produced such a profound effect upon our specialty, that the control of infection has now become a medical rather than a surgical procedure.

Today radical operations on the sinuses aimed at elimination of infection are comparatively rare and mastoid operations for acute mastoiditis are practically unknown.

Even before the discovery of the anti-infection agents, great changes were already taking place in otolaryngologic thinging.

Enthusiasm for radical surgery of the nose and sinuses had begun to wane, partly because results did not always warrant such radicalism and partly because the public refused to submit to such treatment.

Since the discovery of the antibiotics, many other advances in our knowledge in regard to the etiology of ear, nose, and throat symptoms have discredited our earlier belief that infection is the all important factor.

Nutritional Deficiencies. Deficiencies in vitamins, minerals and other nutritional factors were shown by Selfridge,[1] Shurly,[2] Jarvis,[3]

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Jones,[4] Roberts,[5] and others, to be the frequent cause of many ear, nose and throat symptoms which had previously been credited entirely to infection.

Histamine. Horton's[6, 7] experiences with histamine and certain types of headaches, vertigo, tinnitus, and some forms of deafness disproved the idea that infection is the primary etiologic factor in most of these symptoms.

Emotional Factors. Our better understanding of psychosomatic influences and emotional upheavals and their ability to produce many symptoms referable to our specialty still further lowers the percentage of symptoms formerly attributed entirely to infection.

Hormones. The better understanding of the action of the various hormones, particularly ACTH and Cortisone and their effect on ear, nose, and throat symptoms promise to have a very definite important influence on our specialty.

Allergy. The many advances which have been made in our better understanding of what for lack of a better name we designate as "allergy" pioneered in our specialty mainly by Hansel,[8] still further discredits the contention that infection is the primary cause of most ear, nose, and throat symptoms.

The researches of Dean,[9] Proetz[10] Jones,[11] Kuhn,[12] and others established the probability that much of the deafness due to edema of the eustachian tube and the accumulation of fluid in the middle ear is due to allergy and not to infection.

The experiments of Dohlman[13] and Koch[14] indicate that allergy not only prepares the soil for many acute middle ear infections, but also plays a major part in those chronically discharging ears which do not respond to sulfa drug and antibiotic therapy.

The fact that these two investigators, as well as Smirnov,[15] were able to experimentally produce allergic reactions in the middle ears of guinea-pigs and subsequently infect them, seems to indicate that allergy is an etiologic factor in many middle ear inflammations and infections.

These advances make it imperative that the present day Otolaryngologist not only become proficient in surgical technique, but that he also have an adequate background of general medicine.

With the possible exception of the antibiotics, the better understanding of allergy has probably had a more profound effect on treatment of ear, nose, and throat symptoms than has any other influence, and it is with allergy that the main body of this paper deals.

Although allergy is a general disease, it is being recognized more and more as an important etiologic factor in many symptoms referred to the ear, nose, and throat, and patients suffering from these symptoms come first to the Otolaryngologist for relief. For this reason it behooves everyone in our specialy to become familiar with the fundamentals of allergic diagnosis and treatment.

Before discussing specific symptoms in which allergy has been shown to be an etiologic factor, I should like to briefly review with you some of the newer theories of allergy and try to show a definite relationship between these newer allergy concepts and those specific symptoms.

Williams[16] recently published an excellent article in which he reviewed and analyzed much of the important allergic literature of the past few years and from his analysis, suggested an approach to allergy based on Selye's[17] General Adaption Syndrome Theory of Stress.

According to this theory, allergy is considered one of the protective body reactions to stress, in which an overstimulation of a physiologic response, rather than a pathologic factor produces symptoms.

It is believed that typical allergic reactions may be initiated not only by protein sensitivities, but also by emotional upsets and by physical agents. Regardless of whether the initiating factor be house dust, cat hair, shell fish, insect bites, sunlight, or emotional stress, the stimuli follow the same pathways and produce the same type of allergic reaction as an end result.

The allergic reaction takes place in the peripheral vascular bed, when the parasympathetic nerves, which control dilatation of these small vessels gain dominance over the sympathetic system which governs the constriction of these vessels. The resultant dilatation together with increased permeability of the capillary walls permits loss of serum and electrolites into the surrounding tissue, causing edema. This edema produces allergic manifestations.

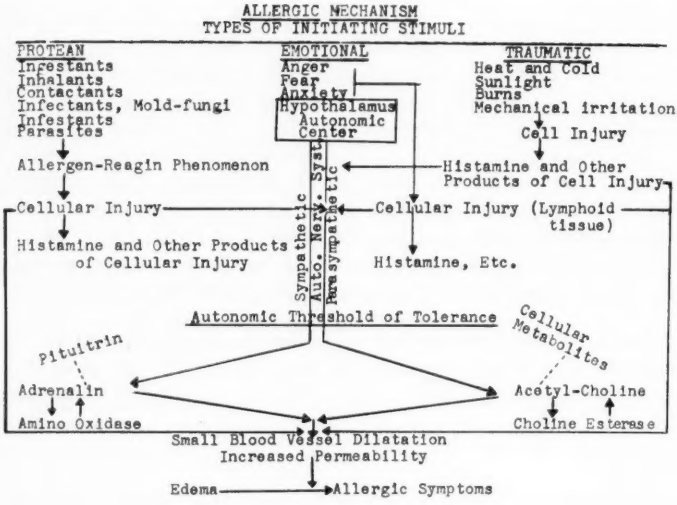

Fig. 1.

Any individual may exhibit allergic symptoms under certain conditions, and the variation in the tendency to autonomic imbalance depends on the individual's personal threshold of tolerance to stress, which may be influenced by heredity or may be acquired—frequently both factors operate. In those individuals in whom cellular activity to injury is great, hereditary allergy is apt to occur, while in those in whom it is of lowest degree, symptoms of allergy may never appear. Between these two extremes of varying degrees of cellular activity, there exists all degrees of allergic symptom probability.

A summary of the theory is shown diagrammatically in the following slide (Fig. 1).

With these present day allergic theories in mind, the following points are presented for your consideration and discussion:

Among the most frequent complaints which cause the patient to seek the services of the otolaryngologist may be mentioned:

(1) Excessive post-nasal discharge

(2) Impaired nasal breathing

(3) Chronic cough

(4) Headache

(5) Acute hoarseness in adults and croup in children

(6) Chronic hoarseness

(7) Recurrent acute sore throat

(8) Impairment of hearing

(9) Vertigo

(10) Symptoms of the common head cold

It is my thesis that allergy is frequently a major etiologic factor in all of these symptoms, and I should like to briefly discuss several of them.

Excessive Nasal Discharge. This very common complaint is often diagnosed "sinus" by the patient or "low grade sinus infection" by the physician. This diagnosis usually leads to much local treatment and even to nasal surgery, many times without any prolonged relief. A cytologic examination of the mucus from the nose or the pharynx will show increased eosinophils in diagnostic numbers in a very high percentage of all patients complaining of this symptom. A short allergic history is usually sufficient to identify a food or an inhalant to which the patient is sensitive as the etiologic factor. Elimination of the food from the diet or a few injections of the proper sized dose of the offending inhalant allergen (house dust, molds, tobacco smoke and newsprint are the most common offenders) will very often relieve this troublesome symptom even after months of treatment aimed at control of infection has failed.

Chronic Nasal Obstruction. This symptom, when not due to anatomical malformation or tumor growth, is very often due to allergy. Again, a short allergic history and an examination of the nasal mucus for increased number of eosinophils will differentiate between infection and allergy.

When due to allergy, hyposensitization to the common inhalants is most effective in relieving this symptom unless tissue changes have become irreversible, in which case, streak cauterization of the turbinates in addition to hyposensitization gives consistently satisfactory results.

Chronic Cough. When no definite etiology can be found for this symptom, allergy should always be suspected. Mucus from the pharynx, larynx or bronchi will frequently show increased numbers of eosinophils. A few injections of the proper sized dose of offending inhalant allergen is often far more effective in controlling this type of cough than unlimited amounts of cough mixture or innumerable treatments with antibiotics.

Acute Laryngitis and Croup. Acute laryngitis in adults and croup in children, when not due to over-use of the voice, inhalation of irritating fumes, or to acute bacterial invasion, are usually due to allergy—particularly food allergy. Again, an allergic history and the presence of increased eosinophils in the secretions will confirm the diagnosis. Treatment directed along allergic principles often gives prompt relief, while penicillin mist, troches, steam inhalations and various other antibiotic therapeutic measures aimed at control of virus or bacterial infection may only aggravate the symptoms.

Chronic Laryngitis. Chronic laryngitis in those patients in whom the vocal cords become chronically edematous and polypoid is practically always the end result of a long-standing neglected allergy in which irreversible tissue changes have taken place. The condition is identical with polyposis of the mucous membrane of the nose and sinuses which condition is now generally recognized as being the result of allergy rather than of infection.

In these patients, an allergic rhinitis is usually present and should excite suspicion as to the true etiology of the laryngeal pathology. Sections of polypoid tissue removed from the cords and stained to show eosinophils will prove the diagnosis of allergy.

Elimination of foci of infection in the teeth, tonsils and sinuses is always good general therapy, but specific allergic management is required to prevent recurrence after the polyposis has been treated surgically.

Recurrent Acute Sore Throat. This symptom is frequently due to inhalant or food allergy. The sore throat may develop quickly following exposure to the inhalant or ingestion of the offending food, and if treated as an allergy, is promptly relieved. Differential diagnosis between infection and allergy under these circumstances is most important.

The Common Cold. It is with the greatest hesitancy that I presume to mention this most controversial subject. But since the Otolaryngologist is constantly called upon to treat this condition and since most acute and chronic sinus infections occur following common colds, it is pertinent, I think, to include a short résumé of the subject in this discussion.

The etiology of the common cold is still unknown.

There is some evidence that colds are due to an invisible, unculturable, filterable agent which is present only in the early stages of the disease. This view dates from Kruse's[18] experiments in 1914 and was subsequently confirmed by Dochez,[19] Mills and Kneeland who were able to obtain 44% successful transmission, both in humans and apes.

Kerr[20] and Lagen, on the other hand, were unable to infect students living in air-conditioned surroundings under ideal climatic conditions. They suggested that if a filterable virus is the cause, the environmental factors and general body responses to them must be considered in the preparation of the soil and to a greater degree than ever before.

In a more recent paper, Kerr[21] states, "I do not believe, personally, that the common cold is contagious or readily spread by ordinary human contacts. I do not think that the filterable viruses play much part in the spread of the disease."

Fink[22] in 1927 did a most interesting piece of research which tends to substantiate Kerr's beliefs. Fink took biopsies from the mucous membrane of the inferior turbinates of individuals suffering from various stages of acute head colds and found the following phenomena to be present:

In the early stages, that is, before the purulent discharge appeared, there was a marked edema and *increase in eosinophils in the stroma*, and in some cases, a marked dilation of the cavernous blood vessels in the turbinates, but *no polymorphonuclear neutrophilic leukocytes*, no dilation of the ordinary arteries and veins, no abnormal increase in lymphoid cells or eosinophils within the lumen of any arteries and veins, and *no bacteria under the epithelium*. Thus none of the classical signs of bacterial infection were apparent in the nasal mucosa in the early stages of the cold. He, therefore, drew

the conclusion that the early symptoms were the result of nerve reflex.

Fink further found that with the appearance of the purulent discharge, polymorphonuclear neutrophilic leukocytes and the dilated capillaries containing them appear under the epithelium. There was less interstitial edema and the eosinophils diminished; there was also a marked increase in lymphocytes, a general leukocytosis and fever. These are the characteristic findings of infection, but in his observations, these symptoms did not appear until from three to five days after the onset of the first symptoms, which would imply secondary infection.

In 1935, the author[23] read a paper before the Pacific Coast Ophthalmological and Otolaryngological Society, presenting the following hypothesis:

(1) The common cold in its early stages is primarily a transient allergic reaction.

(2) This transient allergic state may be caused by an unknown filterable virus, the growth, of which depends upon the failure of the body to adjust itself to unfavorable climatic and physiological environment.

(3) The stage of purulent discharge follows the secondary invasion of the tissues by a variety of different bacteria super-imposed on a vulnerable, allergically prepared mucous membrane; these bacteria may be present within the body itself or may be introduced from without.

(4) Most of the resulting serious complications are due to these secondary invaders.

The allergic theory is given credence by the symptoms which are, nasal congestion with watery discharge from the nose and eyes; sneezing; lack of fever and no leukocytosis; also by the pathologic findings which are, marked local increase in the eosinophils in the stroma and secretion, no increase in polymorphonuclear leukocytes and no bacteria in the tissue.

These are the typical symptoms and pathologic findings present in an acute allergic episode and not those of an acute infection.

In our office, we have repeatedly shown that in the early stages of a cold, the nasal secretions show increased eosinophils, and that as

the cold progresses, the eosinophils disappear and neutrophils take their place.

The rational of the treatment of the acute head cold which we have used for the past twenty-five years is based on the assumption that the common cold, in its early stages at least, is an acute allergy. We believe, and we have case histories of many patients which seem to substantiate this belief that by treating the early stages of a cold as an acute allergy, that this first stage can not only be greatly shortened, but that the purulent stage can many times be entirely prevented.

During these many years, our basic beliefs regarding the etiology and the indications for treatment of the common cold have not changed, and during that time, much scientific and clinical evidence has accumulated which would seem to substantiate the validity of the hypothesis.

Trigger Mechanism. Acute attacks of respiratory allergy are usually produced by one or more of the following predisposing trigger mechanisms:

(1) Exposure to sudden changes of temperature and humidity.

(2) Fatigue, either mental or physical, or both.

(3) Chilling of the body.

(4) Emotional upsets.

(5) Overindulgence in food, tobacco or alcoholic beverages.

(6) Constipation.

(7) Contact with an overpowering dose of inhalant such as dust, pollens, irritating gasses, paint, insecticides, etc.

All of these stresses produce profound impact on the autonomic nevous system by overstimulation of the parasympathetic nerves or understimulation of the sympathetic system.

According to the newer concepts of allergy, the lower the threshold of tolerance to stress and the more unstable the sympathetic-parasympathetic balance, the more apt the individual is to develop allergic manifestations when subjected to any one of these stresses.

ACTH and Cortisone. If the newer theories of allergy are correct, the two hormones, ACTH and Cortisone which are powerful sympathetic stimulators should provide a new approach to the treatment of allergy by attacking the problem at its source—the peripheral vascular bed. This is accomplished by hormonal stimulation of the entire sympathetic mechanism, that is, the autonomic center in the hypothalamus of the brain stem, the adrenal and pituitary glands, the sympathetic nerves themselves, and the tissues at the nerve ends which secrete adrenalin.

It has been said that ACTH and Cortisone may be "ideal blocking agents" in all types of allergy. This may be true, but could it not be that these hormones act directly on the autonomic nervous system in such a way as to hasten the re-establishment of the sympathetic-parasympathetic balance by stimulation of the sympathetics rather than by any blocking action?

There is some indication that a proper-sized dose of house dust or other allergen administered to a specifically sensitized individual may stimulate the adrenal cortex in a manner similar to that produced by an injection of ACTH or Cortisone, and that the results obtained may be due to this stimulation.

Recently, the beneficial effects of ACTH and Cortisone on the allergic state have been frequently reported in the literature.

Because of the scarcity of the hormones, our own experience with them in the treatment of ear, nose, and throat allergies has been limited to patients with chronic allergic rhinitis in whom a polypoid nasal mucosa is present and in whom asthma has developed. We have treated six patients in all. The initial changes noted in all six patients following treatment have been stereotype and dramatic and can be summarized as follows:

(1) The chronic asthmatic symptoms were promptly controlled.

(2) Striking changes were noted in the tissues and secretions of the nose and pharynx.

(a) The pale, edematous nasal mucosa became pinkish red in color.

(b) Small polyps disappeared entirely and larger ones were greatly reduced in size.

(c) The turbinates were greatly reduced in size and the breathing space became much greater.

(d) Eosinophils in the nasal mucus which had been abundant before treatment were much reduced in numbers.

(e) Mucous secretions in the nose and down the posterior pharyngeal wall were greatly diminished.

(f) Lymphoid tissue on the lateral walls of the pharynx changed from pale gray to purplish-red color and were somewhat reduced in size.

These striking changes observed in the pathology and the allergic symptoms are in accord with the newer allergic concepts, that is, hormonal stimulation of the sympathetic nervous system to a point at which it gains dominance over the already overstimulated parasympathetic system, thus re-establishing the normal autonomic balance.

In conclusion, I would like to state that I am quite convinced that allergy is not the cause of all ear, nose, and throat symptoms nor are the hormones the universal panacea which will cure all body ailments. I am quite convinced, however, that allergy as an etiologic factor in many of these symptoms is still not generally recognized by all otolaryngologists and that until the taking of an allergic history and the search for increased eosinophils in nasal and bronchial secretions become routine procedures in the otolaryngologist's office, many allergic conditions will continue to be erroneously diagnosed as infection and so treated.

Until the members of our specialty become allergically conscious and take the responsibility for, and supervise the treatment of their own allergic patients, little progress can be expected in either the understanding or the treatment of this, the most common of all ear nose, and throat pathology.

SUMMARY

(1) Recent advances in the better understanding of the cause of certain ear, nose and throat symptoms have changed the methods of treatment from predominantly surgical to predominantly medical.

(2) Some of the newer theories regarding allergy are discussed and a broader viewpoint presented using Selye's *Theory of Stress* as

a basis of discussion rather than limiting the term to the antigen-antibody theory of immunity.

(3) Specific symptoms arising in the ear, nose, and throat are discussed from the allergic viewpoint as opposed to the infectious viewpoint.

(4) Some evidence is presented that the common head cold in its early stages is primarily an acute allergy.

(5) ACTH and Cortisone are mentioned as potentially important therapeutic agents in the treatment of allergic manifestations occurring in the ear, nose, and throat.

(6) Dramatic changes in symptoms and in appearance of the mucous membrane of the nose and pharynx following ACTH and Cortisone treatment of six patients are reported.

(7) That the injection of a proper sized dose of allergen and that of ACTH and Cortisone may act similarly on the allergic state is presented as a possibility.

(8) A plea is made for better differentiation between allergic and infectious etiologies for ear, nose, and throat symptoms by otolaryngologists.

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XLVIII

HYPERTROPHY OF THE MASSETER MUSCLES

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AND

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In the course of examining a rather large number of patients referred for treatment of parotid tumor, it was noted in several instances that the "tumor" represented an enlargement of the masseter muscle. The first few individuals in whom this condition was noted, presented no unusual symptoms to prompt further study. It was not until the patient described in Case I was seen that detailed studies of this lesion were undertaken. She complained of tiring of her jaws on chewing to the extent that it was impossible for her to chew gum. Thus, it seemed that the enlargement did not represent an ordinary physiological hypertrophy.

Because of the possibility that some type of muscular dystrophy might be responsible for the enlargement, an outline of study was prepared for this and subsequent cases. The program included a complete neurological history and examination by one of us (R. W.), electromyographic studies of the involved muscles, and histopathological examination of a biopsy specimen. These studies have been made on four of the patients and form the basis of this report. Photographs of three other patients who have not submitted to these complete studies are presented in addition.

Gurney,[1] in 1947 reported a case of hypertrophy of the masseter muscle and described the correction of the deformity by removing the lateral portion of the muscle through an external incision. Microscopical examination of the excised tissue demonstrated no pathological abnormality. The pathologist did note that some of the fibers stained poorly. Gurney,[1] cited the publication of Duroux,[2] in 1905

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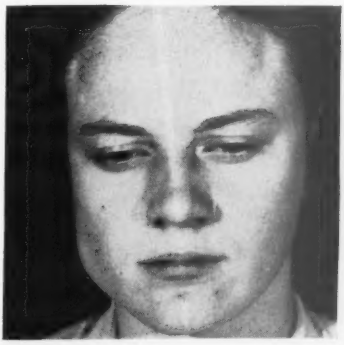

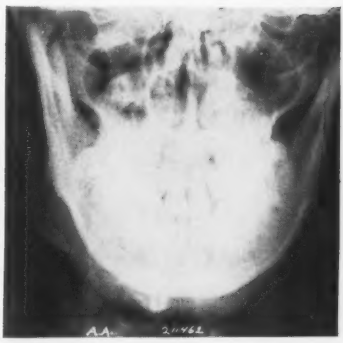

Fig. 1, Case 1.—Preoperative photograph of the patient.

Fig. 2.—Roentgenogram, Case 1.

describing bilateral hypertrophy of the masseter muscles in a man of 22 years, and that of Boldt,[3] describing both unilateral and bilateral involvement. Gurney commented on the obscrure etiology of this condition and suggested that the nervous habit of grinding the teeth, which his patient exhibited, might be an important factor. It is quite probable that such a habit could produce a physiological hypertrophy since it is comparable to the resistance exercises used therapeutically to produce hypertrophy in muscles which have become atrophic from disuse, and to the resistance exercises such as weight lifting used by the body building cults to produce muscular hypertrophy. Thus, grinding of the teeth and repeated clenching of the jaws against resistance would be more likely to produce hypertrophy than active exercise such as habitual gum chewing. However, one would expect under such conditions that hypertrophy of all of the muscles of mastication would be produced.

Adams,[4] in 1949 reported a case of bilateral hypertrophy of the masseter muscles and described a method of correcting the deformity. He excised a segment of the lower, inner aspect of the muscles and removed the protruding angles of the mandibles. "Microscopic study of the specimens removed revealed only normal muscle and bone tissue." This patient apparently had a very wide angled jaw in addition to the hypertrophied masseter muscles. It

Fig. 3, Case 2.—Preoperative photograph.

Fig. 4.—Roentgenogram, Case 2.

was noted that she was not a habitual gum chewer and that so far as known, did not grind her teeth during sleep.

In this presentation, attention is directed to the fact that an individual may have a very wide flaring mandibular angle without masseter muscle enlargement or, may have the muscle enlargement associated with mandibles of normal shape.

CASE REPORTS

CASE 1.—A. A., white female, aged 18 years (Fig. 1). This patient complained of a swelling at the angle of the mandible on the right side which had been noted for about six months. It was thought to have undergone some change in size and shape at intervals but these changes were not in relation to meals. There was mild soreness at the angle of the jaw on the right. She stated that she could not chew gum except for a few minutes due to the aching produced in both sides of the jaw. Even the chewing of a fibrous piece of meat produced this discomfort.

Examination revealed enlargement at the angle of the right mandible readily identified as masseter muscle when the patient would clench her teeth.

X-ray findings are shown in Figure 2.

Fig. 5, Case 4.—Preoperative photograph.

Fig. 6.—Roentgenogram, Case 4.

On neurological examination, it was noted that the pupils were of unequal size, the right being slightly larger than the left and showing a marked hippus. There was some drooping of the right upper lid. The tongue protruded in the mid line but showed a coarse tremor. There was some muscle incoordination on the left side but not on the right. The muscles of the right side of the body were slightly larger than those on the left. The muscles on both sides of the body fatigued quickly.

The electromyogram of the enlarged masseter muscle showed no abnormality.

On August 25, 1948, a piece of the masseter muscle was removed for microscopical examination. Because of the inconstant position of the mandibular ramus of the facial nerve making it vulnerable in external incisions near the angle of the mandible, it was thought advisable to use an intra-oral incision.

Microscopic examination of the excised tissue demonstrated voluntary muscle with most of the fibers well developed. It was noted that some of them were about one-third larger than normal.

Coincidently, the biopsy served to reduce the size of the muscle producing a cosmetic effect quite satisfactory to the patient.

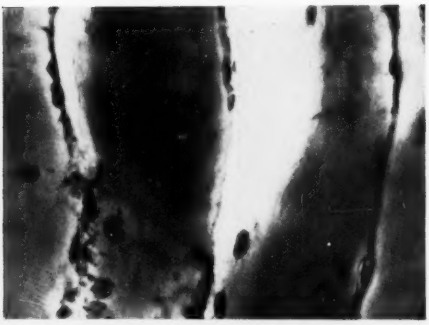

Fig. 7.—Photomicrograph of specimen from Case 4 silver stain.

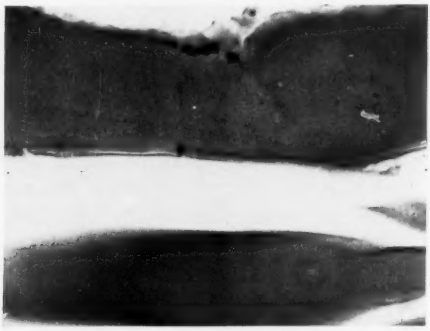

Fig. 8.—Photomicrograph of specimen from Case 4 Masson's stain.

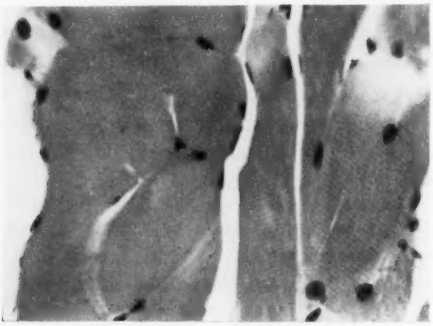

Fig. 9.—Photomicrograph of specimen from Case 4 hematoxylin and eosin stain.

CASE 2.—D. C., white female, aged 29 years (Fig. 3). This patient complained of a swelling of her left jaw that had been increasing slowly in size since it was first noted four years previously. For six months a smaller swelling had been noticed on the right.

Examination demonstrated the bilaterally enlarged masseter muscles with greater involvement on the left.

X-ray findings are demonstrated in Figure 4. It will be noted that there is also considerable flaring of the angles of the mandibles in this patient.

In the neurological examination it was noted that muscle irritability was definitely increased particularly about the shoulder girdle. There was no evidence of muscular incoordination. An electromyogram was not obtained on this patient.

On June 8, 1949, a biopsy of the left masseter muscle was taken through an intra-oral incision. The pathologist noted no abnormality in this tissue.

CASE 3.—J. N., white female, aged 21 (Fig. 10). This patient complained of a swelling of the right jaw present for two years but increasing in size for six months. There had been no pain but the patient stated that the muscles on the right side of the jaw tired more easily than those on the left. She was not in the habit of chewing gum and allegedly did not grind her teeth during sleep.

Examination demonstrated facial asymmetry giving the impression of a right sided hemihypertrophy although the major deformity was due obviously to the enlargement of the right masseter muscle.

In the neurological examination, a marked asymmetry of the entire body was apparent. The left shoulder was carried higher, the left clavicle was more prominent, and the head was held to the right. In closing the jaw, the left masseter muscle contracted first. The definitely slower contraction of the larger right masseter muscle was apparently weaker than the one on the left.

The electromyogram showed about one-half to one-third less voltage on the affected side than on the normal side during voluntary contraction. This lag and change in electrical potential was

Fig. 10, Case 3.

Fig. 11, Case 5.

Fig. 12, Case 6.

Fig. 13, Case 7.

interpreted as indicating either muscle fiber atrophy or a large amount of inactive muscle tissue.

On July 17, 1950, a biopsy of the right masseter muscle was performed through an intra-oral incision. Microscopical examination demonstrated no changes thought to be of pathological significance.

CASE 4.—L. B., white female, aged 17 (Fig. 5). This patient had noted a swelling of her right jaw for about eighteen months and stated that it was increasing gradually in size. Occasionally she had noted a cramping sensation in the right jaw while chewing.

Examination revealed an enlarged masseter muscle on the right side.

X-ray findings are shown in Figure 6.

The neurological examination demonstrated increased irritability of the muscles of the right upper back and slight difficulty in coordination of muscular movement on both sides. The patient was unable to sustain the grip with the right hand as well as with the left.

The electromyogram was within normal limits.

On September 16, 1950, a biopsy of the right masseter muscle was performed through an intra-oral incision. Routine microscopical examination of the excised tissue revealed "no significant abnormality." In this case the muscle tissue was subjected to special staining techniques by the use of silver stain (Fig. 7), and Masson's stain (Fig. 8), in addition to the routine hematoxylin and eosin technique (Fig. 9). In these sections it was noted that some fibers are much larger than others and that striations are absent in the large fibers. Thus, there is a question of some abnormality which defies definite histopathological classification.

Three additional patients with similar findings have been photographed but complete studies have not been done. The first two, Cases 5 and 6 complained of pain like a toothache in the region of the enlarged muscle. Neither was in the habit of chewing gum, and both noticed ease of fatigue of the jaw muscles after prolonged chewing.

Fig. 14.—Roentgenogram of patient with wide flaring angles of the mandible.

Figs. 15 and 16.—Photographs of the above patient.

COMMENT AND CONCLUSIONS

The diagnosis of the condition reported here presents no difficulties although in each instance mentioned there had been a questionable diagnosis of parotid tumor. Inflammatory and neoplastic lesions of the parotid gland and the mandible may be excluded readily by palpation.

In each case it may be noted on the x-ray film that there is a slight prominence of the angle of the mandible. This, however, did not account for the deformity noted. One might speculate that it is secondary to the muscle enlargement since an increase in cortical bone in other locations is produced when a muscle with a broad attachment becomes hypertrophied. This may be seen in the hands of wood choppers whose interossei muscles become greatly hypertrophied, Badgley.[5]

Marked widening of the mandible alone may give a somewhat similar deformity, but in such an instance the smooth, rounded contractile tumor formation of the enlarged masseter muscle is absent. Such an example is seen in the patient pictured in Figure 15 and 16. The wide angles of the mandible are seen to good advantage in the photograph taken from below and in the x-ray film (Fig. 14).

The condition presented here may be of no significance other than its cosmetic effect but there is suggestive evidence that this may be a pathological as well as a clinical entity. The findings which seem worthy of documentation are:

1. These seven cases and two others not included because of lack of photographs, were in females. Two of these patients were 34 years old, and seven were under 30. There was one boy, 11 years of age, examined in the clinic, but not seen by me personally, on whom a similar diagnosis was made (G. P.).

2. The clinical evidence that this condition is not an ordinary physiological hypertrophy is gathered from the history of ease of fatigue of the jaw muscles, the lack of habits conducive to such hypertrophy, and the absence of uniform hypertrophy of all the muscles of mastication. Neurological findings and the electromyograms were generally inconclusive. In one case only was the electromyogram remarkable. There were some mild neurological changes demonstrated but no common denominator presented itself.

3. Although a definite histopathological diagnosis was not made, some apparent abnormalities of questionable significance were noted, consisting of a marked increase in size of some of the muscle fibers which showed lack of striations.

4. Enlargement of the masseter muscle must be differentiated from tumor of the parotid gland and from the congenital wide angled mandible which may produce a similar deformity.

NOTE: Other x-rays submitted but not printed.

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XLIX

SARCOIDOSIS OF THE UPPER RESPIRATORY TRACT

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Through the cooperation of Dr. Bloch in our Chest Clinic who has been making a special study of sarcoidosis of the upper respiratory tract I have had an opportunity to examine a number of such cases. This chronic granulomatous disease is of interest to the laryngologist for a number of reasons. In the first place clinical and autopsy reports indicate that the nose and throat are involved in a high percentage of cases. This may have etiologic significance.

In the second place the lesions in this region may be more readily accessible for biopsy or they may be the only lesions present to produce symptoms. The mucous membrane lesion may appear before the skin is affected.

In the third place the sarcoid lesion may become large enough to produce severe local symptoms as in the sinus or larynx even without producing any systemic signs of the disease.

In the fourth place this is one of the few chronic systemic diseases of unknown etiology that affects the nose and throat and is worthy of study on that account alone.

In the fifth place this disease may produce cervical adenopathy or salivary gland swellings about which the nose and throat specialist may be consulted.

Unlike most of these chronic diseases affecting the nose and throat such as leprosy, tuberculosis or syphilis whose etiology is clearly established, the etiology of sarcoidosis is unknown. Sarcoidosis, according to most authors, is a well-defined clinical entity with predominent involvement of skin, lymph nodes, bones, eyes and lungs. A recent definition of sarcoidosis adopted by a Committee

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This report was prepared with the active cooperation of Drs. Robert Bloch, Stephen Rothman and Eleanor Humphreys of the departments of Chest, Dermatology and Pathology respectively.

of the National Research Council reads: "Sarcoidosis is a disease of unknown etiology. Pathologically it is characterized by the presence in any organ or tissue of epithelioid cell tubercles with inconspicuous or no necrosis and by the frequent presence of refractile or apparently calcified bodies in the giant cells of the tubercles. The lesions may be replaced by fibrosis, hyalinization or both. Clinically the lesions may be widely disseminated. The tissues most frequently involved are the lymph nodes, lung, skin, eyes and bones (particularly the extremities). The clinical course usually is chronic with minimal or no constitutional symptoms. However, there may be acute phases characterized by malaise or fever. There may be signs or symptoms referable only to the tissues and organs involved. The intracutaneous tuberculin test is frequently negative. The gamma globulins are often increased. The outcome may be clinical recovery without radiographically visible residue or there may be impairment of the organs involved or a continued chronic course of the disease."

Although nothing definite is known about the cause of this disease, many investigators have pointed out that it is probably related to tuberculosis. Boeck[1] who described this disease fifty years ago considered it a form of tuberculosis. However, there is at least one biological feature which sharply separates sarcoidosis from tuberculosis. Patients with active tuberculosis have a more or less high degree of sensitivity to tuberculin, whereas sarcoid patients are conspicuously insensitive to it, sometimes reacting negatively to skin injections of as much as 3 to 10 mgm of undiluted tuberculin Eighty to 90 per cent of the cases studied in this clinic had a negative tuberculin test.

The negative skin test to tuberculin in sarcoidosis is associated with a tuberculin-neutralizing activity of the patient's blood serum. If the serum of a sarcoid patient is mixed with old tuberculin and injected intradermally into persons known to be hypersensitive to tuberculin, no skin reaction will develop. This tuberculin neutralizing power is in the gamma globulin. In severely affected cases there is an increase of the globulin fraction with a disturbance of the albumin-globulin ratio. The tuberculin-neutralizing action of the serum is rather characteristic for sarcoidosis, although it is occasionally found in normal serum, and has been reported to occur in Leishmaniasis. Jadassohn and Lewandowski distinguished the anergy in sarcoidosis as "positive anergy" in which the serum has tuberculin neutralizing power from the "negative anergy" which occurs in

terminal stages of tuberculosis when all defense mechanisms have become exhausted. Whereas the negative tuberculin reaction in sarcoidosis would first suggest that this disease is entirely separate from tuberculosis, a considerable number of patients with sarcoidosis develop tuberculosis and at the same time become tuberculin-positive.

There have been two main theories connecting sarcoidosis with tuberculosis. Schaumann[2] assumed that sarcoidosis is caused by abnormal forms of the tubercle bacilli (ultramicroscopic forms or forms with altered staining qualities) in a suitable host. Others[3] have assumed that sarcoidosis is a special phase in the course of tuberculosis in which the host has acquired an unusual insensitivity to the bacillus. Thus, the anergy to tuberculin is explained by some on the basis of acquired infection with the tubercle bacillus.

On the other hand acid fast bacilli are not found in sarcoid tubercles and transmission experiments have been negative.

The histological picture of sarcoid while characteristic is not pathognomonic. Jadassohn and Lewandowsky[4] point out that "where bacteria have unlimited multiplication in the body, the organism responds with a non-specific inflammatory reaction. Where bacteria are slowly destroyed by antibodies; where bacterial proteins are broken down by antibodies or react with antibodies tuberculoid structures result." Granulomas of syphilis, tuberculoid leprosy, beryllium and to a lesser degree of tularaemia, histoplasmosis, blastomycosis and brucellosis may resemble those seen in sarcoidosis. As compared with other chronic granulomas the sarcoid granulomas are rather inactive. They grow slowly, if at all, and rarely undergo necrosis. Histologically, the individual tubercles in sarcoidosis are often miliary in size, round, sharply circumscribed and usually separated from each other by well-developed connective tissue septa. Eggston and Wolff[5] described the sarcoid lesion as many accumulations of reticulo-endothelial cells separated in a thousand island nature. In most localizations, the tubercles are made up by epithelioid cells mainly, with no or few lymphocytes. However, in the biopsies of the nasal mucosa of patients reported here there is a great deal of diffuse inflammatory reaction in the subepithelial layer in addition to the discrete sarcoid tubercles. This inflammatory reaction is probably not specific but results from secondary reactions due to the disturbed physiology of the sarcoid-invaded submucosa. In the epithelioid cell nests of sarcoid tubercle giant cells are often seen.

Giant cell inclusions are sometimes seen, particularly in old lesions, as in other chronic granulomas except tuberculosis. The number of tubercles may increase to the point where they form large, grey, granular appearing masses. Syphilis and leprosy may also produce lesions of this type. According to Dr. Bloch sarcoidosis appears as a single explosive reaction of the body to some agent and then usually continues from that time in varying degrees. In contrast, the clinical course of tuberculosis is one of fluctuating activity.

Sarcoidosis usually occurs in young adults. A median age of 25 is reported in one group studied while Longcope and Pierson[6] observed that one-half of 200 patients contracted the disease before the age of 30. It causes much more extensive lesions in negroes. The involvement of one particular organ may be conspicuous while not easily detectable lesions are widespread. In all cases studied here, the lungs were involved, while other structures were less often affected. The disease attacks lymph nodes in a high percentage of cases, and when present in the neck, carcinoma, Hodgkin's etc. may be considered in the differential diagnosis. Schaumann reports that nineteen of his 20 cases had positive tonsil biopsies. Schaumann also found lesions in the pharyngeal and tracheal mucosa at autopsy. The glands of the mediastinum are often involved to produce mediastinal widening. The skin lesions are not as common but are striking. They appear on the face and other surface of the body and are discrete cutaneous or subcutaneous infiltrates. The eye lesions are serious and occur in a considerable number of cases (50 per cent according to Woods,[8] about 30 per cent of the cases seen in this clinic). Uveoparotid fever (Heerfordt's disease) and Mikulicz syndrome are manifestations of sarcoidosis of the salivary and lacrymal glands.

According to Gifford and Krause[8] the eyes may be painful, the vision may be blurred, nodules of the lids, conjunctivitis, keratitis, uveitis, and iridocyclitis may be found on examination.

The general condition of sarcoid patients is satisfactory in most cases. Symptoms in the lung may arise from obstruction by the infiltrates rather than from toxic causes. Among the patients examined here one died of a sarcoid mass in the brain producing internal hydrocephalus. One had esophageal obstruction due to fibrosis of perioesophageal sarcoid glands. In some patients symptoms of heart failure develop because of the extensive fibrosis of the lungs increasing the circulatory resistance. Symptoms may also be produced

by intercurrent infection facilitated by decreased resistance of organs involved such as the lung. One of the patients reported here died with pulmonary and meningeal tuberculosis. In some cases there is an increased sedimentation rate and elevation of globulins but no leukocytosis. Occasionally there is eosinophilia. Pinner[9] found monocytosis in the active stage. The bone marrow may be widely involved. In the bones of fingers and toes a painless circumscribed central destruction produces a typical punched out appearance on X-ray with or without external swelling. Sarcoid nodules have been found in the nerves, pleura, heart and pericardia, prostate, thyroid and pituitary gland. In a review of the literature Colover[10] found 115 cases of sarcoidosis in which the central nervous system was involved. The liver is commonly involved, and in a recent report by Klatskin and Yesner[11] fifteen out of 20 cases had tubercles in the liver on liver puncture.

The presenting complaint in a group of 20 sarcoid cases analyzed by Vivas, Smith and Jacobs[12] was enlarged lymph nodes in 86 per cent of cases; cough, 20 per cent, weight loss, 19 per cent; skin lesions, 16 per cent; low grade fever, 15 per cent. The disease has natural remissions even after years. Schaumann reports that the sarcoid lesion is replaced by fibrous connective tissue if active tuberculosis developed.

The disease is not common but it is being more widely recognized in recent years. Some 50 cases have been so diagnosed at the University of Chicago Clinics among some 500,000 admissions. The protean nature of the disease with its widespread lesions together with the fact that a similar pathological picture can be seen in some other chronic systemic granulomatous diseases makes the diagnosis difficult especially if biopsy material is not available. Few patients present all the characteristics findings of the disease. Evidence of the disease may be so minimal or be so obscured by a superimposed disease as to escape notice and be discovered only at autopsy. In addition to the histological picture, x-ray evidence of enlarged glands in the hilum of the lung, diffuse fibrosis radiating from the hilum, with or without widespread miliary lung lesions, rarefaction and reticulation of the medulla of the phalanges, anergy to tuberculin, characteristic skin and eye lesions, one may obtain information from the Kveim test. An extract of a human sarcoid lesion is injected under the skin of the suspected case of sarcoid. In six to twelve weeks

a nodular lesion develops in the patient with sarcoidosis at the site of injection which on biopsy shows the typical sarcoid tubercle.

The disease has not responded to treatment with Chalmoogra oil, sulfones, antibiotics, vitamins, phototherapy, streptomycin or nitrogen-mustard. Irradiation has been tried and now there is considerable interest in the use of large doses of vitamin D.[13] The results of this nearly toxic dose of vitamin D have not been definitely established. Our dermatologist, Dr. Rothman, believes it may improve the skin lesion without affecting the disease elsewhere because of a possible selective effect of vitamin D on skin metabolism.

Involvement of the upper respiratory tract in this disease was emphasized by Boeck about fifty years ago. He said that four of his nine cases had a stubborn chronic affection of the nasal mucous membranes, before skin lesions appeared while two others began to have nasal symptoms when the skin lesions appeared on the nose. He biopsied one case and found diffuse inflammation but no tubercles in the nasal mucosa. He believed that the mucous membrane involvement played an important role in this disease and recommended its study by the rhinologist. Schaumann who studied this disease for many years suggested tonsil biopsies for diagnosis stating that nineteen of his 20 cases had positive tonsil biopsies. Following Boeck's and later Schaumann's investigations, an occasional case was recognized by the otolaryngologist. Ulrich[14] in describing the nose and throat findings in two cases, including biopsy of the nasal mucosa also points out that the first sign of the disease may appear in the nasal mucous membrane. He discussed the similarities and differences between sarcoid and lupus vulgaris. His sarcoid patients noted nasal obstruction, dryness and thick discharge and crusting. He found the lesion on the free edge of the epiglottis as well as in the nasal mucous membrane. Pinner's account in 1938 entitled "Non caseating tuberculosis" lists about a dozen cases affecting the nose and throat reported in the literature. Rosedale[15] had a case involving the larynx that required a tracheotomy. There was an irregular grossly lobulated grayish-pink non ulcerated mass involving both true and false cords. There were no nasal lesions but skin lesions were marked on the face. The histological examination revealed sarcoid-like tubercles.

Seifert[16] reported a case in 1939 and Poe[17, 18] in 1940. Seifert's case involved the epiglottis causing partial obstruction, and had skin

and lung lesions. Poe's case had widespread involvement of the upper respiratory tract but the only symptoms were epistaxis and hoarseness. As in other parts of the body these granulomatous lesions may proliferate and require surgical intervention because of their size producing obstruction of the nasal or laryngeal airway. In 1942 Bordley and Proctor[19] described such a case involving the sinuses. Fletcher[20] reported four cases involving the nose and sinuses. One of his cases had identical nasal septum biopsies five years apart without perforation of septum. None of his patients had constitutional symptoms such as fever, weight loss, anorexia, anemia or cough. In three of his patients, the chief complaint was a nasal discharge. None of his patients had lesions anywhere else except the chest—where fibrosis was seen on x-ray. In one case healing by fibrosis of the inferior turbinate over a ten year period ended in atrophic rhinitis without ozena.

Rubin and Kling[21] reported a case in 1948 that had a large septal mass extending into the nasal bones and skin without constitutional symptoms but with a lesion in the phalanx. Their patient did not respond to streptomycin. A number of other cases with upper respiratory tract lesions have been reported in recent years. Wille[22] described the lesions of the nasal mucosa as pinhead size nodules with a hyperaemic zone sometimes running together to cause diffuse yellowish infiltrations.

REPORT OF CASES

This report is concerned with the findings in nine cases of sarcoidosis. All of these have been diagnosed on the basis of other manifestations of the disease and a positive Kveim test.

The first case is that of a twenty-nine year old negro female who was first seen in 1945 complaining of chronic nasal obstruction with dryness and crusting. She reported that her nose bled at her menstrual period. There were hard, infiltrating skin lesions, present since 1942, appearing first on the arm and then on the face. A biopsy of this skin lesion was typical of sarcoid. Swelling of the third finger of the right hand had occurred six months before her coming to the clinic and a destructive lesion involving the base of the proximal phalanx of the third digit was found on X-ray. Although the chest x-ray revealed hilar enlargement she had no constitutional symptoms. No change in the x-ray appearance of the chest or phalanx was noted during several years of observation. The

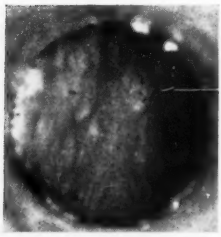

Fig. 1.—Mrs. H. Photograph (enlarged about 7 diameters) of the anterior tip of the inferior turbinate showing one discrete tubercle (see arrow) in a hypertrophic irregular mucosa. The base of the tubercle is about $1\frac{1}{2}$ millimeters in diameter.

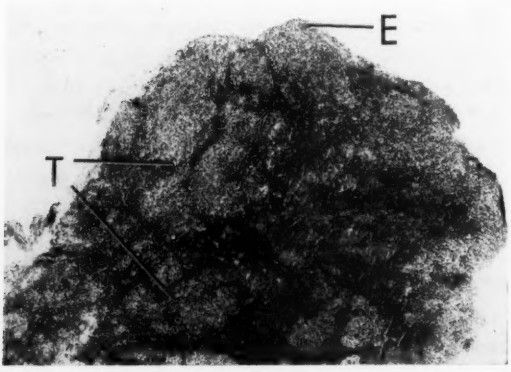

Fig. 2.—Mrs. H. Biopsy in 1946 from inferior turbinate (X63) showing multiple epithelioid tubercles of various sizes and shapes in a diffusely inflamed submucosa. Two groups of tubercles are indicated by T. The epithelial surface is at E.

skin lesions however did improve, the infiltrations being replaced by fibrosis. Her skin test even to undiluted tuberculin was negative. Our first examination in 1945 revealed an irregular thick pale nasal mucosa with crusting and thick purulent secretion. This mucous membrane change extended to the choanae. In addition to the general mucosal involvement pinhead size pale submucous nodules were seen on the right inferior turbinate. A great deal of discharge was washed out of the nose. There were some granulations in the left nasal vestibule, the right Eustachian cushion and in the midline of the vault and a red pea-sized, irregular heaped up area on the mucous membrane over the posterior surface of the epiglottis (Fig. 1). Biopsies of the nasal mucosa revealed considerable inflammatory change in addition to a dense mass of sarcoid tubercles. Six months later the lesions appeared unchanged.

Five years later she still had no constitutional symptoms. Her skin lesions had not recurred. She recalled that crusting discharge and nasal obstruction began about the same time as the skin lesions started and despite the clearing of the skin lesions the nasal symptoms have continued (Figs. 2 and 3). Examination at this time again revealed scattered pale miliary submucous nodules on the right inferior turbinates together with more widespread granular thickening of the nasal mucosa with crusting and purulent discharge. The nasal vestibule and Eustachian cushion however were clear. There was one small pinhead size, red area on the free lip of the epiglottis and the tracheal mucous membrane was red and covered with some secretion. A biopsy of the nasal mucosa now reveals essentially the same histological picture as that seen five years previously.

The next patient, a twenty-nine year old negro male, was seen in 1947, also complaining of nasal obstruction and discharge, worse on arising. Examination revealed a red granulomatous lesion on the left tonsil, posterior lateral band and the right side of the epiglottis. The nasal mucous membrane was red, granular, thick and covered with mucopus (Fig. 4). This patient had fever, malaise, and weight loss of four months duration. He dated the onset of his illness to 1943 when he noted swelling of both eyelids, injected sclerae, and severe pain in the eyes, followed by small nodules in the right upper lid. A year later other skin nodules developed. The skin nodules gradually disappeared by 1946, then new skin lesions

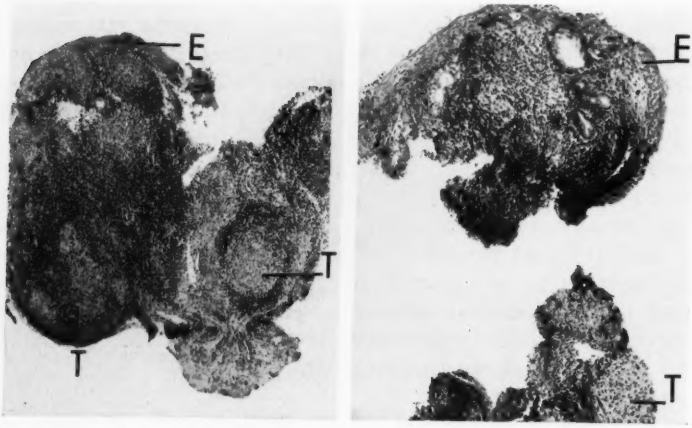

Fig. 3.—Mrs. H. Photomicrograph (X70) of a biopsy from the inferior turbinate obtained in 1951 (5 years after the one illustrated in Figure 2) showing a number of epithelioid tubercles (T) in a densely infiltrated submucosa. A stratified epithelium seen at E, covers the turbinate. The histological and gross appearance of the turbinate remained essentially unchanged during this five-year period.

Fig. 4.—Mr. W. Photomicrograph (X130) of a biopsy from the inferior turbinate. The epithelioid tubercles (T) are in the lower fragment that has fractured away from the more superficial epithelial (E) covered tissue above.

appeared and have remained. He had involvement of the skin, eyes and lymph nodes and diffuse infiltration of the lungs on x-ray and lesions in the phalanges of both the hands and feet. His Kveim test was positive. His tuberculin test which had been negative to O.T. in 1-1000 dilution in 1945, became strongly positive to a 1-10,000 dilution in 1947. Over the next two years this patient went downhill with fever, weight loss and productive cough. He was hospitalized but did not respond to dihydrostreptomycin and para amino salycilic acid. The chest x-ray was now compatible with far advanced pulmonary tuberculosis. He died in 1949 with meningeal, pulmonary and renal tuberculosis and sarcoidosis. At autopsy the liver and spleen were enlarged and there were large, periaortic lymph nodes. Round, yellow nodules are seen on section of the lymph nodes.

Some are pinhead size, others involve the whole lymph node. There was no caseation in the enlarged peribronchial lymph nodes. The liver and spleen, and left adrenal also contain these nodules in section. The lymph nodes are greatly enlarged throughout. There was a firm, irregular, grey granulomatous mass in the subcortical white matter of the occipital lobe.

The next case was that of a fifty-seven year old negro woman first examined in 1946. She had extensive skin lesions and infiltrations of the lung with cough and dyspnoea. During the next three years the cough and dyspnoea became worse but the skin lesions healed by fibrosis. . She had a long history of nasal obstruction, crusting and discharge and a submucous resection was done for this many years before followed by a depression of the nasal bridge. The submucous resection partially relieved the obstruction but did not relieve the crusting and discharge which continued with bleeding. There was some improvement of her nasal symptoms in the last year but hoarseness was noted recently. She had a large surgical perforation of the septum with irregular and crusted edges. The mucous membrane of the inferior and middle turbinate was thick, red, granular, dry and covered with crust. There was a small granuloma on the posterior pharyngeal wall and on the free lip of the epiglottis. A biopsy of the nasal mucosa revealed a diffuse inflammatory reaction in addition to epithelioid tubercles (Fig 5). The Kveim test was positive. Two years later examination revealed that the mucous membrane of the inferior turbinates was not so extensively involved. The epiglottis was now clear of lesions but there was a granuloma on the posterior wall of the pharynx. Nasal irrigations helped to relieve her nasal symptoms.

The fourth case is that of a forty-four year old negro woman first seen in 1945. She had fibrotic lung lesions and lesions in the bones of the right foot and right hand. One eye was severely affected and there were many skin lesions. The tuberculin test was negative. For many years she had nasal symptoms, crusting, discharge and obstruction. She also noted hoarseness and had a productive cough with difficulty in raising the secretions.

The nasal vestibule was deformed and constricted by the skin lesions in this area.

The mucous membrane in the anterior nasal fossa was covered with crusts and a fibrous synechia joined the right inferior turbinate

Fig. 5.—Mrs. C. Photomicrograph (X70) of a biopsy from the inferior turbinate showing a number of epithelioid tubercles (T) in a densely infiltrated submucosa. The epithelial surface is seen at E.

Fig. 6.—Mrs. M. Photomicrograph (X110) of a biopsy from the inferior turbinate showing the relation of a group of epithelioid tubercles (T) to the epithelial surface (E). Giant cells are seen within the tubercles and the connective tissue layer around the tubercles clearly defines them.

with the septum. Pinhead size submucous nodules were present on the thickened inferior turbinate. A sessile granuloma covered with dry secretions was present in the nasopharynx. The true and false cords were red and thick. There was a small granuloma on the anterior tracheal wall.

There was bilateral clouding of the antrum on x-ray. A biopsy of the nasal mucosa revealed sarcoid tubercles and diffuse inflammation (Fig. 6). Two years later the lesions in the respiratory tract had not changed appreciably, the right eye was blind but the skin lesions had improved.

The fifth case is that of a forty-year old negro woman seen in 1946 with lung infiltrates and active skin lesions of six years duration. The conjunctiva was also involved. She had an excessive dryness of the nose, a cronic nasal and postnasal discharge with cough and had a sinus operation in 1945.

Examination revealed a dry, irregular, thick, granular nasal mucous membrane, particularly in the upper part of the septum.

The inferior meati were filled with polypoid tissue coming through antrum windows. The anterior ends of the inferior turbinates had been removed. The nasal mucous membrane was thick, granular and covered with thick, sticky secretions. The mucosa of the pharynx and trachea was also involved. The right antrum was completely clouded on x-ray while the left showed markedly thickened mucous membrane.

A biopsy of polypoid tissue from the antrum window shows submucous miliary epithelioid non caseating tubercles some of which contain giant cells. These tubercles stand out in contrast to the loose connective tissue stroma of the oedematous sinus mucosa. The nose and throat were essentially unchanged two years later.

The next case is that of a twenty-six year old negro woman who had subcutaneous nodules, extensive lung infiltrates, severe involvement of the left eye but no bone lesions. The skin lesion was positive for sarcoid on biopsy. She was examined in 1946, stating that a year ago she noted left sided nasal obstruction which had persisted and gotten worse with occasional anosmia. There was very little nasal discharge and no bleeding.

Two months later she first noted deep, painless skin nodules.

Two months after that the left eye became involved.

The nasal mucosa was hypertrophic, red irregular with miliary submucous nodules. No crusts or thick secretion was seen but there was considerable obstruction. A red thick granular area was present on the tip of the epiglottis and right arytenoid. The mucosa of the trachea, particularly on the anterior wall, was hypertrophic, irregular, red and nodular.

A biopsy of the nasal mucosa revealed infiltrations and tubercles (Fig. 7). A year later this patient died elsewhere with a sarcoid mass in the brain.

The seventh case is that of a thirty-year old negro woman who had iritis, hilar masses and skin lesions. She was first examined in 1946. She had noted right nasal obstruction with crusting and bleeding for the past eight months. There were miliary pale submucous

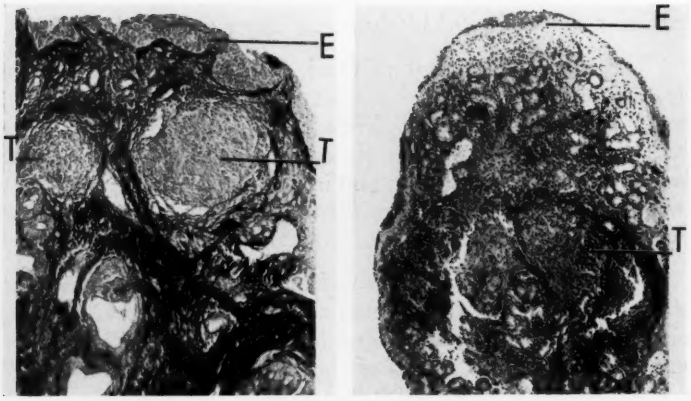

Fig. 7.—Mrs. J. Photomicrograph (X250) of a biopsy from the inferior turbinate specially stained to show the connective tissue stroma in relation to two epithelioid tubercles (shown at T) and the overlying epithelium (E). Glandular elements are seen in the lower half of the illustration.

Fig. 8.—Mrs. W. Photomicrograph (X130) of a biopsy from the inferior turbinate. On gross examination this turbinate appeared normal except for two pin-head size submucous nodules. One is seen at T in relation to the epithelium E. The subepithelial layer and glandular bed appear relatively free of inflammatory reaction.

nodules on an irregular, hypertrophic nasal mucous membrane with crusting only involving the right side of the nose. The rest of the nose and throat examination was negative. The biopsy of her nasal mucous membrane reveals inflammation and tubercles in the submucosa. Two years later the nasal findings and biopsy were unchanged.

The eighth case is that of a forty-eight year old white female with an eye lesion starting fifteen years previously. Pulmonary and bone lesions appeared ten years later. She had breathing difficulty and a productive cough but no nasal symptoms. The antrum mucous membrane was thickened on x-ray and on the anterior end of the left inferior turbinate were two pinhead sized, submucous nodules that bled a little when touched. There were epithelioid tubercles on histological examination (Fig. 8).

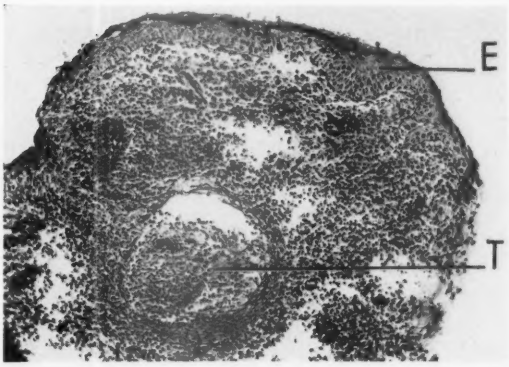

Fig. 9.—Mrs. K. Photomicrograph (X200) of a biopsy from the involved inferior turbinate in a case of lupus vulgaris showing one tubercle (T) surrounded by fibrous tissue in a submucosa densely infiltrated with inflammatory cells. The epithelial surface is seen at E.

A ninth case, that of a thirty-six year old negro male, with skin, bone and lung lesions had no nasal symptoms but his nasal mucous membrane revealed pinhead sized submucous nodules on the left side of the septum and left inferior turbinate. No biopsies were taken in this case.

The distribution of sarcoid lesions in the upper respiratory tract of these nine cases is summarized in Table 1.

DISCUSSION

With the exception of leprosy and lupus there are relatively few chronic granulomatous diseases of the respiratory mucous membrane with which sarcoidosis can be confused. Ulrich called attention to the similarities in the nasal involvement of Lupus and sarcoid. Wille also says that lupus vulgaris produces a picture in the nasal mucosa closely resembling that seen in sarcoid. We followed one case of lupus vulgaris with nasal involvement. This patient had a hyperplastic red mucosa studded with pinhead sized red, not yellowish, submucous miliary tubercles. The section did show epithelioid tubercles and a rather diffuse inflammation of the submucosa with some giant cells in the stroma. The lupus infiltrations in the skin are also composed of non-caseating tubercles and persist for

TABLE 1.

DISTRIBUTION OF SARCOID LESIONS IN UPPER RESPIRATORY TRACT.

Patient	Nose	Sinuses	Nasopharynx	Pharynx	Epiglottis	Glottis	Trachea
Mrs. H. (1946)	x		x		x		
" 1951)	x				x		
Mr. W.	x			x	x		
Mrs. C. (1946)	x			x	x		
" (1948)	x			x			
Mrs. M. (1946)	x	x	x				x
" (1948	x	x	x				x
Mrs. R. (1946)	x	x		x			x
" (1948	x	x		x			x
Mrs. J.	x				x	x	x
Mrs. A. (1946)	x						
" (1948)	x						
Mrs. W.	x	x					
Mrs. M.	x						

years but they are more diffuse than the rather distinctly separated sarcoid tubercles. The involvement of lungs, bones and lymph glands are very different in these diseases and in lupus the tuberculin test is strongly positive. However, there is some superficial similarity between the two insofar as they may develop active tuberculosis of the lungs and that they usually remain in good health for a long time.

In our case of lupus vulgaris there was marked improvement in the skin lesion after a course of vitamin D but unlike the response in the case recently described by Priest[23] the appearance of the nasal mucosa had not changed. Histologically, too, there was no appreciable change in the nasal mucosa after treatment. It is true that

this case was treated with moderate doses of vitamin D. High doses of vitamin D used by some investigators for treatment of lupus and sarcoidosis may produce calcification of the renal tubules and other serious toxic effects. No definite change in the systemic disease has been shown in the cases of sarcoid treated here with moderate doses of vitamin D.

None of the sarcoid cases so treated showed a definite improvement of the nasal lesion. Furthermore, none of the sarcoid lesions in the nose was seen to heal spontaneously by fibrosis and atrophy. Some of the small granulomas in other regions did clear up spontaneously without noticeable scarring. While some patients were followed for several years, the extreme chronicity of the disease would make it necessary to observe cases for a long time before seeing changes in the affected organs. The histopathology of the nasal lesion helps to explain the hypertrophy with obstruction, the nodular appearance and the pathological secretion.

SUMMARY

The general clinical and pathological features of sarcoidosis that separate it from other chronic systemic granulomatous diseases are reviewed briefly.

The relation of the nose and throat to this systemic disease is considered and the findings in nine thoroughly studied proven cases with nose and throat lesions are presented. Sarcoid lesions were found in the inferior turbinate of all eight cases biopsied. Some of these lesions were unchanged even after five years while others disappeared spontaneously without noticeable scarring.

A characteristic appearance of the nasal mucosa affected in sarcoidosis is that of pale miliary submucous nodules in a hypertrophic nasal mucosa with various degrees of crusting and discharge. This could be explained by the histological findings in seven cases of diffuse inflammatory reaction of the submucosa, small non-caseous epithelioid tubercles and metaplasia of the epithelial layer. In some cases these tubercles collected to form larger discrete granulomas. In one case the nasal mucosa appeared everywhere normal except for two miliary submucous nodules in the anterior tip of the inferior turbinate.

For differential diagnosis, a case of Lupus Vulgaris with nasal mucous membrane involvement was described with biopsy findings.

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Society Proceedings

CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY

Meeting of Monday, December 4, 1950

THE PRESIDENT, DR. SHERMAN L. SHAPIRO, IN THE CHAIR

Experimental Studies of Negative Pressure Produced by Respiratory Cilia

JOHN J. BALLENGER, M.D.

(Abstract: Complete article on page 694, Annals, September, 1950)

An attempt was made to develop a negative pressure by ciliary action in the excised trocheas of rabbits and in the frontal sinuses of dogs. In the first case an occluding diaphragm of mucus collected from other rabbits was inserted into the pulmonary end of the trochea and, as the mucus was moved upward, a negative pressure averaging approximately 5 mm of water was measured.

In the latter part of the experiment the mucus collected from the other dogs was placed in such a position as to occlude the frontonasal duct. The mucus then was moved down the duct by ciliary action and a negative pressure developed within the sinus. This negative pressure averaged 24 mm of water in 12 experiments on eight dogs.

DISCUSSION

DR. ALFRED LEWY: The apparent differences in pressure measurements between those of Dr. Ballenger and Dr. Hilding might be explained by the difference in humidity in the surrounding atmosphere. I do not think those slight differences would in any way vitiate the experiments.

DR. OLIVER E. VAN ALYEA: I wish to commend Dr. Ballenger for repeating this work of Hilding. Though it seems a simple investigative problem it is, nevertheless, full of value. Some years

ago we apparently did not regard ciliary activity as highly important in either the upper or lower respiratory system. Hilding has brought this to our attention in showing, among other things, the great strength of this ciliary mechanism. It seems important that this be thoroughly understood if we wish to progress in the therapy of conditions involving the respiratory tract.

Perhaps the upright position would explain the variation in the results of the two experiments. Naturally, the frontal ostium being located in the most dependable portion of the sinus, there is a great pull downward but quite a distance to travel before the production of negative pressure. This undoubtedly accounts for the pain which occurs in the morning with frontal sinusitis, and it is brought about as the individual assumes the erect position and the accumulated exudate starts on its downward passage through the ostium.

I hope that Dr. Ballenger will continue with this work and that he will enlighten us on any information gained on the activity of the ciliary mechanism.

DR. SAMUEL SALINGER: I think there is another factor that might explain the end result obtained by Dr. Ballenger as compared with those obtained by Hilding, namely, the relative size of the sinus. We have no information as to the size of the sinuses in the Hilding animals as compared to the Ballenger animals. Differences in the capacity of the sinuses may be a factor in the results obtained.

Another item might be the question of the nasofrontal duct. I do not think we need lay too much stress on the fact that there is a difference in negative pressure which depends on the caliber of the nasofrontal duct. What impressed me was that a plug of mucus being carried by ciliary activity toward the ostium can product negative pressure, which satisfies the claim that many laryngologists have held for years, that a vacuum may be produced. It was the etiology that was a matter of dispute.

DR. HANS VON LEDEN: I would like to commend Dr. Ballenger, and to ask a few questions. First, has he observed any difference in the negative pressure depending upon the length of time the animal had been dead? Is there a rapid decrease in pressure in a period of hours or minutes after death? The second point, which Dr. Salinger mentioned, is not the strength of the mucus sheet dependent upon the size of the lumen? I wonder if that explains the differences in the experimental animals of Dr. Hilding and Dr. Ballenger.

DR. JOHN J. BALLENGER (closing): I wish to thank those who commented on the paper. It is stimulating to have people take an interest in the work I have done.

Postmortem examinations were made on these animals. In none of the frontal sinuses in the dogs were there any postmortem changes such as grossly discernible thickened mucous membrane or blood. From that one might conclude tentatively that a negative pressure of 24 mm of water was not sufficient to cause gross damage in the mucous membrane of the frontal sinus.

Dr. Lewy mentioned the humidity; that, in work with cilia, is the most important single thing to control. Dryness is a natural enemy of cilia. We are all familiar with Dr. Proetz's suggestion that the pathogenesis of the common cold may lie in dryness. A blast of inspired air constantly strikes one spot in the nasal mucous membrane so that it becomes dry and devoid of overlying mucus. The cilia in that area are then stopped and one barrier to sepsis is removed. In these experiments I did the best I could to control humidity.

Dr. Salinger mentioned the size of the sinuses and the vacuum. We attempted to assume that the air had been absorbed, and having made that assumption, calculated the cubic centimeters and the rapidity with which air was absorbed. When that was compared with the surface of the lung it became apparent that if the first assumption were true, the sinus surface can absorb oxygen more quickly than the alveolar surface, which is an untenable assumption. The great difference must be explained by removal of the mucus down the frontonasal duct without replacement of its increased vacuum by gas. Once the negative pressure had developed in the frontal sinus, that negative pressure was maintained for as long as four hours without any particular change in the level of negative pressure. I did not let any animals go longer than four hours. Presumably negative pressure would be maintained as long as the cilia did not completely remove the mucus from the nasal duct. The animal might be dead for two or three hours and there would still be negative pressure.

There is a difference in the size of the lumen in the trachea of the rabbit and the hen, which may explain the differences in our tracheal experiments and those in the literature. In one of Hilding's articles he reported obtaining negative pressures in only two of the three dogs. In the third animal, postmortem examination showed a very wide fronto-nasal duct which, he felt, explained the lack of negative pressure.

Carcinoma of the Esophagus

CHARLES B. PUESTOW, M.D.

CHICAGO, ILL.

(Abstract)

In a period of four years, 80 patients with carcinoma of the esophagus were admitted to the Veterans Administration Hospital at Hines, Illinois. There were only 37 whose condition permitted operation. The majority of the patients had extreme weight loss and a long history of dysphagia, and were in the terminal stage of the disease when first seen.

The essential history in all cases is one of anorexia, progressive dysphagia, substernal discomfort and weight loss. Carcinoma of the esophagus should be suspected in any patient who presents an unusual subjective sensation on swallowing. This symptom demands careful roentgen examination and, if any irregularity or suspicious areas are seen, esophagoscopy should be performed. A biopsy should be taken of any areas of ulceration, inflammation or new growth to establish the diagnosis.

In those patients who are operable, intensive efforts should be made to correct the marked nutritional deficit usually present, before operation is attempted. Blood transfusions, fluids by mouth or parenterally, and special diets to insure the maximum intake of proteins, vitamins, etc., should be administered, and evaluation made of cardiac, respiratory, hepatic and renal function. Other special studies are carried out if indicated.

The surgical technic employed in lesions of the lower, middle and upper thirds of the esophagus is described and illustrated by means of lantern slides, and the importance of adequate post-operative supervision is stressed.

In summary, the essayist called attention to the fact that resection of the esophagus with esophagogastrostomy affords some relief in an otherwise hopeless disease. The high mortality rate is due chiefly to the poor nutritional state of the patient which results from late diagnosis and delay in treatment. Early diagnosis can enable the operation to be performed with relative safety and can increase the possibility of a permanent cure or added longevity and comfort for more advanced lesions.

Unfortunately, in this series of 80 patients, only four were operated on sufficiently early for curative resection to be performed.

In spite of the fact that all patients in the group were seen late in the disease, with emaciation, marked weight loss and advanced nutritional disturbances, the operative mortality for the first thirty days after esophagectomy and gastroesophageal anastomosis was only 33 per cent. In those patients operated on sufficiently early for curative resection to be accomplished, no deaths occurred in the first postoperative month.

DISCUSSION

DR. WILLIAM E. ADAMS: Dr. Puestow's paper covers a subject in which I have had continued interest since we started work on it a number of years ago. His presentation has been so complete that my remarks will be limited to emphasizing some of his points.

The question of early diagnosis, as in all malignant tumors, is important in these cases. If the surgeons who care for these patients can stimulate their early recognition, as Dr. Puestow said, it will make a great difference in the percentage of cures.

I should like to show a few slides to bring out some of these points. The first is a microscopic section through the entire length of a so-called scirrhous tumor, in contrast to the medullary type in which the mucosa tends to overlap the tumor. If the biopsy includes only the mucous membrane it will be negative; a deeper bite will be positive. These tumors spread through the entire thickness of the wall of the esophagus. That means we have to remove as much of the surrounding tissue as possible and, as Dr. Puestow said, enough of the organ in each direction to get beyond the limits of the tumor. I find more and more that the lesion should be removed above the arch of the aorta instead of below.

These next slides have to do with x-ray diagnosis. Most roentgenologists would say this represents a case of achalasia. This patient actually had treatment for achalasia for a year and a half until dilatations gave no relief. On exploration she was found to have an inoperable carcinoma involving the diaphragm and retroperitoneal structures. Operation was performed to sidetrack the lesion and she immediately gained weight and lived for nearly two years, dying from the carcinoma.

Another condition of which we hear relatively little is congenitally short esophagus. These lesions produce gradual stenosis just above the cardiac end of the stomach. Endoscopic examination may show a benign biopsy of the mucosa. At the time an exploratory operation was performed on this patient, in 1947, the tissue appeared to be pliable, and there was nothing to suggest carcinoma. A side-

tracking operation was done to relieve the symptoms and about two years later the patient began to have stomach trouble and died of hemorrhage from a perforating ulcer. At autopsy an adenocarcinoma was found in the region of the gastro-esophageal junction. We have had three cases in which a carcinoma developed at this point in the presence of a congenitally short esophagus. If this possibility is kept in mind, diagnosis is possible in most of these cases.

Lesions of the middle third of the esophagus are notorius for giving poor results, so much so that some institutions will not accept these cases for operation. This patient had a large tumor which extended so high that it was necessary to do an anastomosis above the arch. This was a very fungating tumor, the only one of its kind we have had. It is a papillary lesion of fairly low grade malignancy. Every once in awhile these tumors are found, and whether located in the middle third or elsewhere they are amenable to cure. This patient has gone four years without evidence of recurrence.

For patients who have inoperable lesions we have felt it worth while to relieve the symptoms by this sidetracking operation. We have done this in 12 patients and, although they did not survive for long, immediately following operation they were relieved of obstructive symptoms and were able to take food without a gastrostomy tube. In most cases the fundus can be brought up and a lateral anastomosis made. The operative risk is minimal.

I agreed with Dr. Puestow that the value of antibiotics has been overemphasized in this field of surgery. I also agree that pre- and postoperative care of these patients is of utmost importance. In our experience, if good surgical principles are followed, the main cause of operative deaths is a cardiovascular lesion and it is our feeling that with the use of anticoagulants this cause will be less as time goes on.

Dr. Graham once said that future outlook for bronchogenic carcinoma depended largely on the ability of those who are dealing with those patients to continue to keep up hope; if they lost hope the cause was lost. I am sure this is also true with carcinoma of the esophagus and cardia. We know these patients can live as long as thirteen years after resection, because that is true of the first patient upon whom Dr. Phemister and I operated in February, 1938. We must continue working with the medical profession as well as the laity in order to achieve an early diagnosis.

Dr. Paul H. Holinger: Certainly Dr. Puestow has brought before us a timely subject. We all recognize the surgical aspects of this disease, yet there is sometimes a lag of a year or more between

the time the patient first complains of symptoms and the time endoscopic examination is made; and often a second lag between the time of histologic diagnosis and surgery. Frequently the endoscopist is in the position of advising the patient to have surgery, while the surgeon advises against it on the ground that the lesion is inoperable. There is also the problem of the patient who is relieved of pain by endoscopic dilatation and therefore refuses surgery, as well as the physician who advises against surgery only to have his patient demand it six months later. Thus we have the problem of convincing the physician as well as the patient.

From the standpoint of the endoscopist, I want to compliment Dr. Puestow on stressing the preponderance of accidents in removing tissue for biopsy and the danger of an occasional perforation of the esophagus. Those who have had that happen know that it is a catastrophe. Yet we know carcinoma of the esophagus may be overloked if we hesitate to take a deep bite of tissue because of the hazard of perforation. If we accept the possibility of perforation as one of the hazards of attempting to obtain a diagnosis, we may arrive at the stage of referring patients at an earlier time for surgical procedures. If the condition of the patient is satisfactory, we may make a more radical attempt to arrive at a diagnosis, rather than adopt a policy of watchful waiting.

At times there are differing viewpoints between the endoscopist and the surgeon but on one point we are agreed, that is, that surgical therapy as demonstrated by Dr. Puestow is the only therapy upon which we can rely to offer the patient not only comparative relief, but a possible cure of his disease.

DR. STANTON FRIEDBERG: We have been impressed with the diagnostic difficulties encountered in some patients with esophageal lesions. It has been my good fortune to work with Dr. Puestow in the series he presented, and I would like to stress, as did Dr. Adams, the confusion which may arise from roentgenologic and endoscopic angles. There is a condition which is receiving increased consideration, namely, esophageal ulcers and the strictures which follow their healing. The roentgenographic appearance in some of these lesions can be misleading. There may also be localized ulcers associated with diaphragmatic esophageal herniae. The esophagitis which often occurs with diaphragmatic hernia may mislead one into a tentative diagnosis of malignancy. This necessitates adequate and possibly repeated biopsies. Should these measures not be sufficiently conclusive, exploratory operation is indicated. Achalasia is sometimes difficult to distinguish from carcinoma of the esophagus roentgenographically.

Whenever there is doubt it is only logical to stress the importance of exploring the lesion surgically before too much time is lost. At surgery it is surprising how much more extensive is the lesion than one would assume from roentgenologic or endoscopic examination. We might mention a series of patients who had undergone vagotomy for peptic ulcer at Hines Hospital. In about 23 per cent of the patients there was a complaint of dysphagia, usually without demonstrable evidence of organic trouble. Following resection of esophageal carcinoma, the patients we observed were much more comfortable but a sizeable proportion still complained of difficulty in swallowing. Just why we do not know. Dr. Puestow and I have discussed this many times and have decided that we have a great deal to learn about the physiology of the esophagus. Some of the patients who have had resection of the esophagus are unable to gain weight even though physically they have been rehabilitated and are feeling much better.

In conclusion, we might mention the role of the endoscopist in the care of the occasional narrowings which develop at the site of anastomoses following esophageal surgery. The immediate postoperative care of these patients requires thorough and perhaps repeated tracheobronchial aspiration for prevention of pulmonary complications.

Dr. Robert Lewy: In covering the diagnostic and differential diagnostic problems involved, we have dwelt very well upon organic disease. For probably very good reasons, functional disease is not discussed. In my own practice, both public and private, I have seen a high incidence of the condition known as globus hystericus, to the degree that we felt obliged to take x-rays. The symptomatology in many patients with blobus hystericus may be similar to ulcer symptoms, and to carcinoma or stricture of the esophagus. It is quite a problem to know one is justified in doing x-ray and esophagostopy in these individuals.

Dr. Thomas Galloway: We should have a screening process to discover early carcinoma of the esophagus. At Cook County Hospital we tried using a large capsule with barium to pick up early obstruction with no particular success, but the method has possibilities.

The young men here probably never heard of the Soutter tube made of coiled German silver wire inserted through the malignant stricture, which gave the patient three or four months longer, but he did not have a happy life with it. Carcinoma is one of the greatest tragedies in medicine. Early surgery, compared to Dr. Puestow's demonstration, was crude. I described more than twenty years ago

an operation on cancer of the cervical esophagus. The esophagus was immobilized and a plug of gauze was put behind, isolating the tumor. After seven days further manipulation carried little danger. The esophagus was cut above and below the tumor and the cardiac end was brought out below and the esophageal end was tied over a tube brought up through the wound. One patient on whom we did this operation lived three months and died of recurrent carcinoma of the larynx. It has been shown in the dog that re-epithelization will take place over a defect of 4 to 6 cm. Dr. Lennon and I worked out this operation on some twenty dogs. We passed a tube through the esophagus, inverted its upper end over a knot, mobilized the esophagus and then pulled it through a gastrostomy wound, ligating at the cardia. We passed a stripper like a large vein stripper along the esophagus, and surprisingly we could pass that stripper down to the cardia and, in the dog, got no bleeding we could not control with diathermy with the long esophageal electrode. We had no dog die of hemorrhage, and in the dog the operation did work. I have never heard of anyone trying it on a human being.

DR. CHARLES B. PUESTOW (closing): A review of our patients upon whom esophageal resection has been performed for lesions not involving the stomach discloses a mortality of 16 per cent during the first two postoperative weeks. The death rate during hospitalization of these patients is higher because many patients in V. A. hospitals have no place to go and, if they are debilitated, often remain in the hospital for many months until they finally die of their disease. The mortality rate for resections involving the lower esophagus and upper stomach has been only 5.5 per cent during the first two postoperative weeks.

Much has been written about stenosis or obstruction at the site of gastro-esophageal anastomosis. We have seldom encountered this difficulty. As mentioned by Dr. Friedberg, some patients have difficulty swallowing although endoscopic examination reveals an adequate lumen at the site of anastomosis. Evidently some physiologic disturbance produces the dysphagia.

Lesions of the middle third of the esophagus which lie behind and apparently invade the posterior wall of the arch of the aorta, present a difficult problem. In attempting to free such lesions, we have occasionally perforated the tumor and entered the esophagus. When this occurs it is necessary to complete the resection although it is impossible to remove the entire tumor from the aorta. Many of these patients survive for months or longer and are comfortable, able to swallow food and improve their nutritional state. When

they eventually die of their malignancy the terminal state usually is non-painful. We have operated upon a number of patients whose diagnostic studies suggested an extensive carcinoma of the lower end of the esophagus but who, at the time of operation, were found to have a benign stricture. These have had a resection or a plastic procedure, following which they have led a comparatively normal existence.

I enjoyed Dr. Adams' discussion. He and Dr. Phemister deserve a great deal of credit for the many contributions they have made to surgery of the esophagus and of the proximal portion of the stomach. They have been pioneers in this field and have added much to our knowledge.

Dr. Holinger indicated that we do disagree, but I do not think it is serious; I certainly know that his attitude is similar to ours and that his ability is unsurpassed.

Dr. Friedberg has brought out some most interesting points. I think we have a great deal to learn about the physiology of the esophagus, the relationship of vagotomy to it, and also the etiology of esophageal ulcers. We are just beginning to become interested in this organ and I am sure in the next ten years much progress will be made.

I do not know whether I will try the operation mentioned by Dr. Galloway, but I admire the courage he had in trying that procedure when surgery of the esophagus was at such an early stage and presented dangers of mediastinitis and infection deep in the neck.

Abstracts of Current Articles

EAR

Preaural Tympanic Surgery (Poppin's Approach).

Johgkus, L. B. W.: Acta Oto-Laryn. XXXVIII - VI - Dec. 1950 pp. 498 to 524.

25 fenestrations and 3 cases of atticotomy for cholesteatoma are reported. The author describes the technique of the preaural supratympanic approach. He considers it no more difficult but more delicate than the Lempert Technique. He feels that there is less operative trauma, and the duration of the operation, and of the post-operative healing is shorter. However the operative space is limited making instrumentation extremely delicate. Of his 25 fenestration cases 17 showed satisfactory results at the end of one year. In four, improvement was only transient and six cases were unsuccessful, four of these being due to operative injury.

HILL.

The Effect of Dimenhydrinate Upon the Labyrinth (An experimental study)

Termin H., Van Deinse, J. B., and Hammelburg, E.: Acta Oto-laryn XXXVIII VI Dec. '50 pp. 543-549.

The effect of dramamine upon the vestibular system of rabbits apparently was exerted upon the function of the otoliths and seemed to confirm the labyrinthine theory of sea-sickness. Large doses in these animals produced a disappearance of all labyrinthine reflexes. This was considered to be a "cramp condition" with certain central reactions such as accelerated respiration, dullness and atony, and indicated the importance of caution in dosage. Symptoms of unilateral extirpation of the labyrinth were completely compensated by administration of the drug.

HILL.

Temporary Deafness Following Exposure to Loud Tones and Noise.

Committee on Medical Research of the Office of Scientific Research and Development: Hallowell Davis, Supervisor; Clifford T. Morgan, Co-Supervisor; Joseph E. Hawkins Jr.; Robert Galambos; Franklin W. Smith. Acta Oto-Laryngologica, Supplementum LXXXVIII, 1950.

As stated in the preface this monograph is a slightly abbreviated form of a report of experimental work carried out in 1942-43, the summary of which was published in the Laryngoscope of January, 1946. It consists of some 56 pages including numerous graphs. The work is based upon the studies of the effect on the hearing of 19 men of exposure at repeated intervals of frequencies of 500, 1000, 2000, and 9000 at 110, 120, and 130 db for periods of 1 to 64 minutes. While temporary impairment regularly was produced there was no evidence of cumulative injurious defects. The greatest hearing loss occurred at about ½ octave above the exposure tone. With brief exposure the loss was confined within two octaves above the exposure tone. With longer exposure this extended to all frequencies above the exposure tone. The loss was found to develop most rapidly during the first minutes of exposure. Recovery began rapidly but progressed more and more slowly especially for the higher frequencies. Considerable individual variation was noted in the degree of susceptibility, the range affected, and in the rate of recovery. The impairment was of the nerve levels as well as the distortion of pitch perception. Little or no loudness-loss was produced at the 100 db loudness-level. The modification of loudness-perception was found to be more complex and variable than hithertofore described, either for nerve deafness or for masking, as it diminishes rapidly as the intensity of the sound is increased.

Exposure to a pure tone that causes a hearing loss restricted to a narrow frequency range may give rise to diplacousis with the displacement of pitch largely above the exposure tone. Exposure to a band-spectrum noise which causes a wide-spread hearing loss in the upper frequency range rarely results in diplacousis.

The authors suggest the desirability of some test of susceptibility to acoustic trauma in order to avoid needless exposure to injury but show that the variation in susceptibility even in a given individual on different occasions would make this of extremely doubtful value. From their studies they conclude that the audiogram alone does not furnish an adequate measurement of auditory function. The ability to understand speech where there is interference by masking or following exposure to loud sounds does not depend entirely upon auditory acuity.

HILL.

NOSE

Osteomyelitis of the Maxilla in Patients with a History of Lues.

Dr. Abel Sticco: La revista de Medicina y ciencias afines, Buenos Aires, Argentina, No. 5 (No. 133) pp. 155-157 (May) 1950.

A maxillary osteomyelitis in a patient with a luetic history is reported. This is different from a purely syphilitic osteomyelitis. It has been described as being insidious in onset and of gradual progress (about 15 days) without any acute episode: "Chronic since the beginning" with the formation of small amounts of foul pus and slight fever. The general condition was good. The author states that in 518 cases of maxillary osteomyelitis, 10% were found in patients with a syphilitic history.

The author concludes that lues, even when treated, sensitizes the maxilla, predisposing it to osteomyelitis and that bismuth and mercury treatment increases this sensitization.

The symptoms are 1) Slow onset—chronic from the beginning. 2) Uneventful course. 3) Low fever—37.5. 4) Small amount of foul pus.

Penicillin is believed to accelerate the improvement.

VERA E. MIGUEL.

THROAT

Concerning the Question of Abscess-Tonsillectomy.

Maurer, Rolf: *Neue Medizinische Welt*, 1:1664-1666 (Dec. 16) 1950.

The author reports on his experience in performing tonsillectomy during the acute stage of peritonsillar abscess. Under local anaesthesia (infiltration of one-half per cent Procaine solution) the tonsil is dissected free down as far as the lower pole, and the excision completed by means of a wire snare. Between October 1945 and October 1949 one hundred eleven cases of peritonsillar abscess were handled in this way. The dissection goes directly into the abscess cavity and leaves it wide open in the floor of the tonsillar fossa. In general, the results were satisfactory; healing was not delayed. In two of the one hundred eleven cases, there were serious complications: in one, a lung abscess; in the second, thrombo-phlebitis of the internal jugular vein.

HARKINS.

ESOPHAGUS

The Treatment of Esophageal Diverticulum by Inversion.

Coburn, D. E.: *N. E. Journ. Med.* 244-21 May 24, 1951 pp 791-795.

The author considers the inversion operation to have many advantages as it eliminates many complications which may arise from an open esophagus. There is little or no danger of sepsis with infection of the mediastinum since the sac is not opened. While it has not been considered applicable to large diverticula, many of these are found to actually be quite small after the overlying fascia has been removed. Following the procedure the inverted sac appears as "redundant fold of mucous membrane" and by the end of one year will have decreased to only a slight ridge in the posterior wall. Technique is described and three cases reported.

HILL.

BRONCHI

Chronic Bronchopulmonary Suppuration Secondary to Pharyngoesophageal Diverticulum.

Rafael Hipolito y J. Haracio Rosaico: La verista de Medicina y ciencias afines; Buenos Aires, Argentina, No. 6 (No. 134) pp. 232-236 (June) 1950.

The observation is made of a pharyngoesophageal or Zerker's diverticulum complicated with a chronic bronchopulmonary infection.

The patient has had a cough for five years, mainly after eating, and sensations of fullness and dysphagia localized in the third interspace, with occasional vomitus in which food ingested the previous day was identified. The patient fainted on one occasion after eating. He states that he has been coughing and raising foul, purulent, bloody sputum. X-ray of the chest shows infiltration in the right upper lobe.

Chronic bronchopneumonia with bronchiectasis and hemoptysis was diagnosed. Because of the dysphagia for solids and liquids, the esophagus was examined. X-ray showed a pharyngoesophageal diverticulum.

Under local anesthesia the diverticulum was invaginated following Girard's technic.

Santy explains the fainting following meals by the dilatation of the diverticulum causing carotid sinus pressure. The pneumonic

process is explained as secondary to the emptying of the diverticulum when the patient is recumbent and sleeping, probably with a diminished cough reflex. Part of the ingested material drains into the trachea and bronchi, producing a septic and a chemical (lipid) pneumonia.

VERA E. MIGUEL.

MISCELLANEOUS

Decompression of the Facial Nerve.

Terracol, J., and Guerrier, Y.: Revue de Laryngologie Otologie Rhinologie, 71: 385-388 (Sept.-Oct.) 1950.

Two cases of facial paralysis are presented, both in adults. The first occurred suddenly and without apparent cause four months prior to surgical intervention. The second case occurred following trauma (basilar skull fracture, with bleeding from the ear, followed by purulent otorrhea) three months prior to surgical intervention. In both cases the sense of taste was not affected. In both instances there was loss of response in the nerve to the faradic current, and a reaction of degeneration in the muscle with the galvanic current. In both cases decompression of the facial nerve was carried out; the nerve sheath was incised. Both patients made a good recovery, with return of almost normal function in the affected facial nerve.

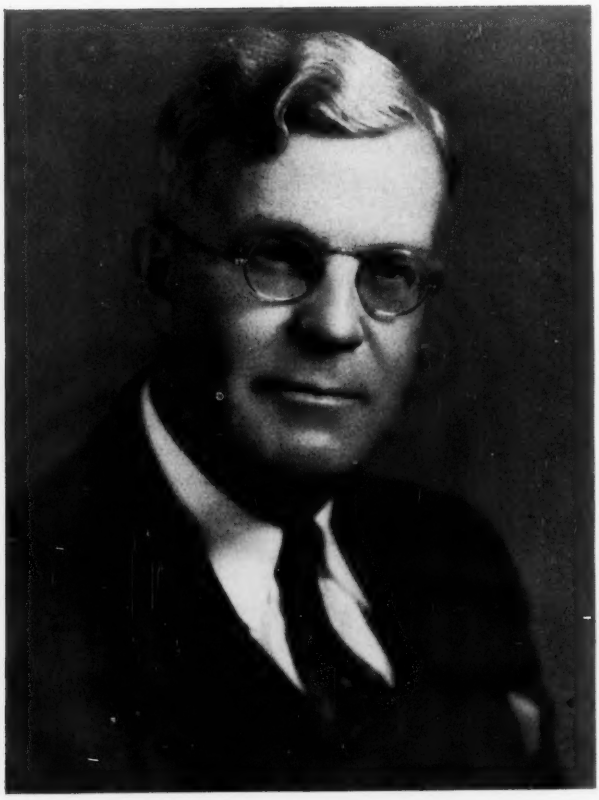
HARKINS.

Cervical Spondylo-Arthritis with Medullary Compression Due to a Foreign Body in the Esophagus.

Guerrier: Revue de Laryngologie Otologie Rhinologie, 71:214-217 (May-June) 1950.

The author reports a case of a foreign body (chicken bone) lodged at the upper end of the esophagus, which resulted in osteitis of the fifth and sixth cervical vertebrae. The foreign body had remained in situ for twenty-five days, prior to removal by esophagoscopy. There was destruction of the involved vertebrae and compression of the spinal cord in this area, with quadriplegia. Laminectomy was carried out and pressure on the involved portion of the spinal cord was relieved. Immobilization was continued for one month. Recovery of function was complete.

HARKINS.



WILLIAM E. GROVE
1882-1951

WILLIAM E. GROVE, M.D.

1882-1951

Dr. William E. Grove, a nationally known otolaryngologist of Milwaukee, met his death on March 31 as he and Mrs. Grove were returning over mountain roads from a winter vacation in North Carolina.

Dr. Grove, who had retired from active practice in November, 1950, was born in Madison, Wisconsin. He received the degree of Bachelor of Arts at the University of Wisconsin in 1904 and his medical degree at Johns Hopkins University in 1908, after which he came to Milwaukee where he developed a large and successful practice. In later years he was interested particularly in the eye and ear, and more particularly in hearing conservation.

He was a fellow of the American Academy of Ophthalmology and Otolaryngology, the American Laryngological Association, the American Otological Society and the American Laryngological, Rhinological, and Otological Society. At some time he held offices in most of these organizations and served as president of the Otological Society in 1947. For many years he was a member of the American Board of Otolaryngology, where he was regarded as the champion of fairness and impartiality.

One of his particular interests was the amelioration of noises in industry and he was prominent in the committees on conservation of hearing, both of the American Academy and the State of Wisconsin, acting for some years as chairman of the latter. As a member of this committee he was instrumental in helping to promote a program for the periodic examination of all school children in the state. In his home city he helped to organize the Milwaukee Hearing Rehabilitation Clinic at Marquette University, where he held the chair of otolaryngology from 1936 to 1950, when he became Professor Emeritus. He was at one time president of the Milwaukee Oto-Ophthalmic Society.

Until the time of his death he was actively engaged in contributing to the literature of the specialty and the programs of the societies to which he belonged.

Surviving him are Mrs. Grove, three daughters: Mrs. Henry C. Behning, Oregon, Illinois; Mrs. Frederick C. Marsh, Omaha, Nebraska; Mrs. S. B. Slocum, Milwaukee, Wisconsin; a sister, Mrs. J. N. Jessup, Wooster, Ohio, and a host of sorrowing friends.

Books Received

Cleft Palate and Speech.

By Muriel E. Morley, B.Sc., F.C.S.T., Speech Therapist to the Royal Victoria Infirmary, The Hospital for Sick Children, and The Newcastle General Hospital, Newcastle-upon-Tyne. Foreword by Professor T. Pomfret Kilner, C.B.E., F.R.C.S., Nuffield Professor of Plastic Surgery, University of Oxford. Second Edition. Pp. xx+160, with 56 figures. Baltimore, The Williams and Wilkins Company, 1951.

Atlas der Hals-Nasen-Ohrenkrankheiten.

By C. von Eicken and A. Schulz van Treeck, Eine Sammlung typischer Krankheitsbilder mit topographischen, diagnostischen und therapeutischen Hinweisen (a collection of typical pathological pictures with topographic diagnostic and therapeutic observations). Third Edition. Pp. 200 with 470 illustrations, many in color. Georg Thieme Verlag. Agents for U.S.A. Grune and Stratton, New York, 1951.

Traité de Technique Opératoire Oto-Rhino-Laryngologique.

By George Portmann, Professeur de Clinique oto-rhino-laryngologique à l'Université de Bordeaux, Oto-rhino-laryngologiste de l'Hôpital Bellan (Paris), Membre correspondent de l'Académie de Médecine. Second Edition. Pp. 1012 with 531 illustrations and 2 plates in color. Paris, Masson & Cie, 1951. (Price 5800 fr.)

Allergy: Facts and Fancies.

By Samuel M. Feinberg, M.D., Associate Professor of Medicine, Chief of Section of Allergy and Director of Allergy Research Laboratory, Northwestern University Medical School. Attending Physician, Passavant Memorial Hospital. President (1942-44) *American Association for the Study of Allergy (now American Academy of Allergy). Foreward by Austin Smith, M.D., Editor of the Journal of the American Medical Association.* Pp. xiv + 173. New York, Harper and Brothers, 1951. (Price $2.50)

Your Sinus Troubles and Treatments.

By Friedrich S. Brodnitz, M.D. Pp. x+243. New York, Abelard Press, 1950. (Price $2:50)

Notices

AMERICAN BOARD OF OTOLARYNGOLOGY

The American Board of Otolaryngology will conduct the following examination:

October 9-12, in Chicago, Illinois, at the Palmer House.

DEAN M. LIERLE, M.D., *Secretary*
University Hospital,
Iowa City, Iowa

UNIVERSITY OF ILLINOIS

For the period of the National Emergency, the University of Illinois College of Medicine will offer a combined three year residency training program in Otolaryngology, which will include the basic course material, in fulfillment of Board requirements.

Residents will rotate through the Research and Educational Hospitals, the Illinois Eye and Ear Infirmary, the Hines Veterans Administration Hospital and the various affiliated institutions. The residency will be so flexible that should it be interrupted because of military service, the period of training may be resumed upon returning to civilian life.

Under this arrangement, no course fee is to be involved and in the case of most of the aforementioned institutions, a stipend is provided.

For further information, kindly address; Head of the Department of Otolaryngology, University of Illinois College of Medicine, 1853 West Polk Street, Chicago 12, Illinois.

HOME STUDY COURSES

The 1951-1952 Home Study Courses in the basic sciences related to ophthalmology and otolaryngology, offered as a part of the educational program of the American Academy of Ophthalmology and Otolaryngology, will begin on September 1 and continue for a period of ten months. Registrations must be completed before August 15. Detailed information and application forms may be secured from Dr. William L. Benedict, the executive secretary-treasurer of the Academy, 100 First Avenue Building, Rochester, Minnesota.

PLASTIC SURGERY

The Foundation of the American Society of Plastic and Reconstructive Surgery offers Junior and Senior Awards for original contributions in Plastic Surgery.

Junior Award: 2 Scholarships in Plastic Surgery of 6 and 3 months respectively. This is open to plastic surgeons in the specialty not longer than 5 years.

Senior Award: For the best essay on "Mass Treatment of Burns in Atomic Warfare."

The winning essays will be part of the program of the forthcoming annual meeting of the American Society of Plastic and Reconstructive Surgery to be held at Colorado Springs, Colorado, October 31-November 2, 1951.

Entries must be received by the Chairman not later than August 15, 1951.

The Award Committee
c/o Jacques W. Maliniac, M.D.
11 East 68th Street
New York 21, N. Y.

THIRD PAN-AMERICAN CONGRESS

The Pan American Association of Oto-Rhino-Laryngology and Broncho-Esophagology will hold its Third Pan American Congress of Oto-Rhino-Laryngology and Broncho-Esophagology in Havana, Cuba, in 1952.

For information address: Dr. Chevalier L. Jackson, 3401 N. Broad Street, Philadelphia 40, Pa.

ANNALS

The management of the ANNALS desires to buy, at $1.50 each, copies of the following numbers which are out of print:

March, June, 1940

March, June, 1943

March, Sept., Dec., 1944

March, June, Sept., Dec., 1945

March, Dec., 1946

June, Sept., 1947

March, Dec., 1948

March, 1950

HEARING AIDS ACCEPTED BY THE COUNCIL ON PHYSICAL MEDICINE AND REHABILITATION OF THE AMERICAN MEDICAL ASSOCIATION

(As of June 1, 1951)

Audicon Models 400 and 415
Audivox Model Super 67
Aurex Model F
Aurex Model H

Beltone Harmony Mono-Pac
Beltone Symphonette Model
Beltone Mono-Pac Model M

Cleartone Model 500
Cleartone Regency Model

Dahlberg Model D-1
Dysonic Model 1

Electroear Model C

Gem Model V-35
Gem Model V-60

Maico Atomeer
Maico UE Atomeer
Maico Quiet Ear Models G & H
Maico Model J
Mears (Crystal and Magnetic) Aurophone Model 200
1947-Mears Aurophone Model 98
Micronic (Magnetic Receiver) Model 101
Micronic Model 303
Micronic Star Model (See Silver Micronic)
Microtone Audiomatic T-3
Microtone Audiomatic T-5
Microtone Classic Model T-9
Microtone Model T-10
Microtone Model 45

National Cub Model (C)
National Standard Model (T)
National Star Model (S)
National Ultrathin Model 504
National Vanity Model 506

Otarion Model E-1S
Otarian Model E-2
Otarion Model E-4
Otarion Models F-1, F-2 and F-3
Otarion Model G-1 (Whisperwave)

Paravox Model J (Tiny-Myte)
Paravox Models VH and VL (Standard)
Paravox Model XT ('Xtra-Thin)
Paravox Model XTS ('Xtra-Thin)
Paravox Model Y (YM, YC and YC-7) (Veri-Small)

Radioear Permo-Magnetic (Multipower)
Radioear Permo-Magnetic (Uniphone)
Radioear All-Magnetic Model 55
Radioear Model 62 Starlet
Radioear Model 72
Rochester Model R-1
Rochester Model R-2

Silver Micronic (Magnetic and Crystal) Models 202M and 202C (See Micronic)
Silvertone Model 103BM
Silvertone Model J-92
Silvertone Model M-35
Silvertone Model P-15
Solo-Pak Model 99
Sonotone Model 600
Sonotone Model 700
Sonotone Model 900
Sonotone Models 910 and 920
Sonotone Models 925
Sonotone Model 940
Super-Fonic Hearing Aid

Televox Model E
Telex Model 22
Telex Model 97
Telex Model 99
Telex Model 200
Telex Model 300-B
Telex Model 400
Telex Model 1700
Tonamic Model 50
Tonemaster Model Royal
Trimm Vacuum Tube Model 300

Unex Model A
Unex Midget Model 95
Unex Midget Model 110

Western Electric Models 65 and 66

Vacolite Model J

Zenith Model 75
Zenith Miniature 75
Zenith Model Royal

(All the accepted hearing devices have vacuum tubes.)

Accepted hearing aids more than five years old have been omitted from this list for brevity.

TABLE HEARING AIDS

Aurex (Semi-Portable)
Precision Table Hearing Aid
Sonotone Professional Table Set Model 50